POWER

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Concentration

WHEN you sit down to a game of cards, checkers or some similar pastime, you do not permit your mind to wander to other things, at least not if you expect to win. On the contrary, your sole purpose for the time being, is to make as good a score as possible. Consequently you give the contest your undivided attention. If you lose, it is because luck was against you, or your opponent played a superior game. Certainly you never lost because your "mind was not on the race."

When it comes to prosecuting your calling —that which is the means of procuring your bread and butter—do you concentrate with equivalent intensity?

You would not attempt to enter into a game until you had digested the rules pretty thoroughly, for you realize that your chances of winning depend largely on your knowledge of them and your ability to apply them effectively at the right time.

Similarly the mastery of the principles of a science such as steam engineering, is the first essential toward playing a successful part in its application. The question of how to succeed, although ages old, is in truth simple and easily answered. In its shortest form the answer is the single word, "concentrate." We use the term in its broadest sense, to include both physical and mental activity. Continuously apply the same intensity of thought and effort to your daily work that you do to your favorite pastime and you will succeed.

Close attention to the study of a subject leads to complete knowledge thereof, while a roving mind, at best, will be but half informed. A man may be a slow thinker, but if he centers his entire attention on his task, excluding all else and resolutely persisting with the one idea in mind, he will accomplish greater results than a man of much more ability, but whose thoughts are distracted by new ideas and plans for future work or play, allowing him to stumble from one error into another.

So much then for mental concentration.

The other important factor in the battle to achieve is concentration of effort. "Bunch your hits," as they say at the ball grounds. Do the work that you now have to do, both routine and special, the best you know how, and make sure that you know the best way. Apply all the rules of the game and be thorough.

It is widely and wisely quoted that "The reason why the man who minds his own business succeeds is because he has so little competition." Do not make the mistake of trying to play every position on the diamond, for you never could "get away with it." Concentrate on your own. That little position which you hold down is probably plenty big enough for you at present. If it is not, it is only a question of time before you will progress to a bigger one.

In the meantime it does no harm to wait and work!

Practical Flue Gas Analysis

By Harry A. Cox

A knowledge of chemistry is not necessary to operate the Orsat. Read the following article and see how easy it is to interpret results and reduce the amount of coal burned.

Some writers claim that to operate an Orsat requires a knowledge of chemistry. It naturally follows that, since the average engineer's knowledge in this branch of science is limited, he is loath to interest himself in any instrument with these requirements. However, such is not the case for an ordinary fireman will easily learn how to operate an improved gas-analysis instrument, such as is shown in Fig. 1, and interpret the results obtained. The instrument can be bought all set up and ready for the chemicals which are furnished with the outfit. The instructions are so plain that no man need have any difficulty.

The three gases entering into the combustion of coal that need to be taken into account are carbon dioxide (CO_2), oxygen (O) and carbon monoxide (CO). It is desirable to keep the percentage of carbon dioxide as high as possible without obtaining carbon monoxide.

The accompanying table for which the author is indebted to Joseph B. Hays, shows the saving to be made by proper furnace operation.

Per cent. CO_2	Air excess per cent.	Fuel loss per cent.	Preventable loss per cent.
15	38.0	12.0	1.0
14	47.8	13.0	2.0
13	59.2	14.0	3.0
12	72.5	15.0	4.0
11	88.1	16.0	6.0
10	107.0	18.0	8.0
9	130.0	20.0	11.0
8	158.7	23.0	14.0
7	195.7	26.0	18.0
6	245.0	30.0	24.0
5	314.0	36.0	33.0
4	417.0	45.0	48.0
3	590.0	60.0	78.0
2	935.0	90.0	....

The data refers to pure carbon, so for anthracite the results given will be nearly correct, but a little high for bituminous coal.

The factors which make a furnace efficient are the proper distribution of air through the fuel bed, methods of firing which will keep the percentage of carbon dioxide comparatively constant, absence of air leakage between the furnace and damper, proper adjustment of the draft and lastly the human factor.

Take, for example, a boiler fired with No. 1 buckwheat coal and test for the distribution of air. The sampling pipe is placed at a point where the flue gases leave the heating surface on its way to the damper and as near the center of the current of flue gases as possible. Connect the inspirator to the Orsat and sampling pipe and with a freshly covered clean fire on the grate draw a sample of gas and analyze it for carbon dioxide. As soon as the fire has become incandescent draw another sample and analyze it. This percentage will be larger than the first. Then when the fire has burned through and holes show on the grate, analyze a third sample. This result will be smaller than the other two. It will be noticed then that a green fire does not need as much air as an incandescent bed of fuel, and that a fire full of holes is not conducive to a high percentage of carbon dioxide, because the resistance of the fuel bed is decreased and too much air is admitted to the furnace.

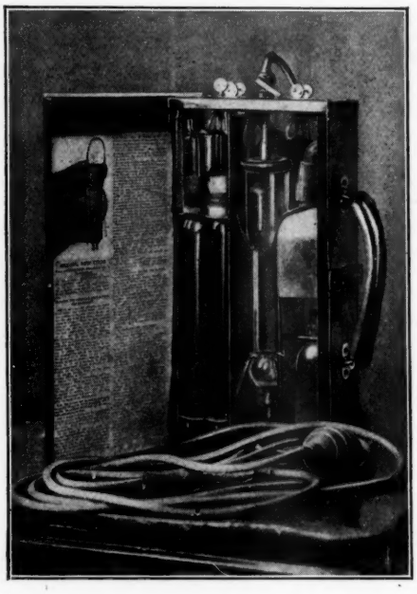


FIG. 1. APPARATUS FOR FLUE GAS ANALYSIS

It is important to keep the fire level and free from holes, especially along the side walls, corners and between the doors. Low carbon dioxide indicates that too much air reaches the fire, so partially close the ashpit doors and use the Orsat as before and a position of the doors will soon be found for various thicknesses of the fuel bed.

After the fire has been burning for a time and is getting dirty, analyze for oxygen and carbon monoxide. Probably from ½ to 1½ per cent. of carbon monoxide with a low percentage of CO_2 will be obtained. It is then time to clean the fire, for there are clinkers on the grate and incomplete combustion is taking place. According to a report of the Bureau of Mines, 1 per cent. of carbon monoxide lowers the efficiency of the furnace 20 per cent.

Fig. 2 shows the relation of carbon dioxide, oxygen and carbon monoxide to the supply of air. These readings were taken from a boiler before any changes were made in the firing or draft. It may be noticed that as the air supply increases, due to holes in the fire, the carbon dioxide decreases and when the air supply becomes insufficient the carbon dioxide runs up as high as 16 per cent., with the formation of excessive carbon monoxide, as there is not enough air for complete combustion. This condition is shown at 2:15 and 4:15. At 7:30 the clinkers interfered with the air distribution and carbon monoxide was formed with a low percentage of carbon dioxide.

It has already been noted that the carbon dioxide drops when the whole grate is covered with fuel at one time, as the temperature of the furnace is lowered beyond the point at which the gases will ignite. To keep an even furnace temperature and a more constant percentage of carbon dioxide, it is better to cover one-half or one-third of the grate at a time.

As previously noted clinkers cause a double loss in lowering the carbon dioxide and causing the formation of carbon monoxide. The writer has learned these facts with the Orsat: Do not disturb the fire more than is absolutely necessary. Fire level instead of using a leveling bar. If the grate is of the shaking and dumping type, do not use it to break the clinkers except during the cleaning period, for as soon as the grate is opened the fine ash and a great deal of live fire is dropped into the ashpit and the clinkers remain on the grate. Use plenty of water on the green coal as the evaporation of the water tends to prevent clinkerous formation. Do not cut down a fire for it takes more coal to level it than to clean it. So when the percentage of carbon dioxide begins to drop, due to a dirty fire, clean it.

Every particle of air, entering the boiler beyond the fire, is raised to the temperature of the flue gas and sent up the chimney at a dead loss. This amounts to from 1 to 5 per cent. in different plants. Take a candle and examine the setting for leaks, also around the inspection doors and those to the combustion chambers, where the door frames fit the setting, where the blowoff pipe comes through the wall and where the breeching fits the setting. If a Babcock & Wilcox boiler, look for leaks at the point where the flues are blown and around the doors on the boiler fronts.

Asbestos putty will stop the leaks except on the doors and to decrease the

leakage at these points coat the door jam with shellac and stick on a single strand of asbestos wicking. After this has been done, try the Orsat again and it will probably be necessary to readjust the ashpit doors for the different thicknesses of the fire.

To attempt any further economy a draft gage and flue-gas pyrometer are necessary. The least draft that can be used, and still keep up steam without the formation of carbon monoxide, is the best for the coal pile. With this end in view connect the draft gage to the boiler in the same manner as the Orsat. Take account of the thickness and condition of the fire, position of ashpit doors and damper, then draw a sample of flue gas and analyze it. Increase the draft and analyze another sample. If the percentage of carbon dioxide is increased more draft is needed, but if the carbon dioxide is decreased cut down the draft as it is already excessive. A thin fire requires less draft than a thick one, and within certain limits the greater the draft the higher the temperature of the escaping flue gases.

Some engineers advocate a flue-gas temperature of 100 to 150 deg. above that of the steam. For instance, if the steam pressure is 150-lb. gage, its temperature being 366 deg., then the flue-gas temperature should range from 466 to 516 deg. These temperatures require economizers to regain some of the heat, but with no economizer these high flue-gas temperatures represent a loss of 20 or 25 per cent. of the heat value of the fuel, unless a large amount of draft is necessary for combustion. So where no economizer is used it is more economical to carry the flue-gas temperature from 40 to 80 deg. above the temperature of the steam.

If a thin fire is necessary in any boiler, coal can be saved by decreasing the draft. A short time ago the writer saved 300 lb. of coal in 6 hr. by reducing the draft on one boiler to 0.24 in.

Fig. 3 shows a chart taken from the same boiler as Fig. 2. While not perfect it shows how nearly constant the carbon dioxide can be kept. With the use of the Orsat, draft gage and pyrometer a saving of 1.3 lb. of coal per kilowatt-hour was made.

This question of flue-gas analysis has a human factor. Results require the cooperation of the fireman. Some plants having a continuous CO_2 recorder, pay the fireman a bonus for a high daily average of carbon dioxide; others post the daily averages of their men on a blackboard and engender a spirit of rivalry. With only the hand instrument it is necessary to get the men interested in some other way.

In the first place, the fireman does not shovel coal because he wants to. He would be happy if he were shown how to keep up steam without that labor. When the Orsat is brought into the boiler room, show the instrument to him and explain what it is for. Teach him to operate it and do not be afraid to let him use it. Tell him what per cent. of coal can be saved by increasing the carbon dioxide and work out each step together. He will then begin asking questions and make suggestions, and when he has been shown the answers with the Orsat, he will be interested and it will be an easy matter for him to analyze the results obtained with the apparatus.

To obtain carbon dioxide averages over a longer period of time, it will only be necessary to assemble a collecting bottle as described in the third section of Mr. Terman's article, recently published. When all this work has been done and the results are studied it will be found that the coal consumption has been reduced and the fireman's knowledge of his work has been greatly increased.

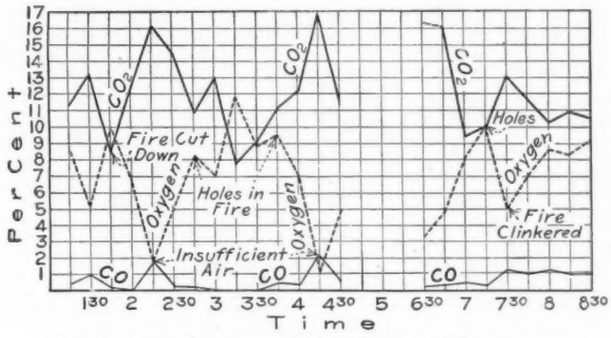


FIG. 2. GAS ANALYSIS RECORDS FROM WATER-TUBE BOILER USING NO. 1 BUCKWHEAT COAL

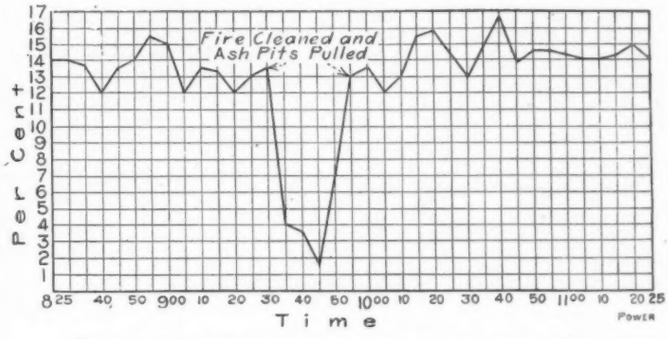


FIG. 3. CO_2 CHART FROM SAME BOILER USING NO. 1 BUCKWHEAT COAL

Hunting for Engine Troubles

BY C. A. GILSON

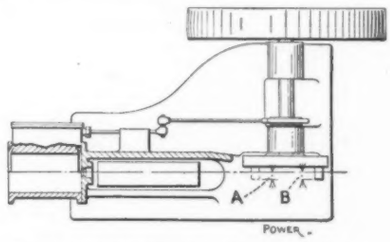
An engine that has steam leaking around the piston rod or that gives two distinct knocks in the wrist at each revolution, is not a very good recommendation for the engineer in charge. A few simple tests may assist in locating the cause of the trouble.

The crankpin may be out of line with the center line of the engine shaft. To test for this fault remove the connecting-rod and level the main shaft. The crankpin should then be tested with a level and should prove level in any position. If it is out of level in any position, the crankpin is out of line. The pin can be easily tested with calipers to see whether it is worn out of round.

Wear and cutting in the main bearing, due to a heavy belt pull, a poor job of babbitting or a mistake in adjusting the quarter-boxes, may throw the engine shaft out of line.

To realign the engine, remove the cylinder head, crosshead, piston and piston rod. Then run a line through the center of the cylinder and stuffing-box, as shown in the sketch. This line should be carefully centered either by using an X-centering device in both cylinder and stuffing-box or by using calipers.

Fasten the line at some point beyond the crank and turn the crank to a point near the head-end center and measure the distance *A* shown in the illustration. Then turn the crank to the opposite center and carefully measure the distance *B*, as shown. If these two measurements are equal, the engine is in line; if not, the shaft should be shifted in the proper direction. Some times the shaft can be realigned by adjusting the boxes, preferably the bearings farthest from the crank. A shaft seldom needs endwise adjustment, as a mistake in design would be the only cause of this fault.



LINE CENTERED IN THE ENGINE CYLINDER

A leaking stuffing-box may be caused by the piston rod and crosshead guides not being parallel; this causes the piston to have a slight vertical motion together

with the regular sliding motion. This vertical motion destroys the packing and may cause the rod to bind and heat in the stuffing-box.

Worn or badly adjusted crosshead shoes may throw the piston rod out of line with the guides. The piston rod can be tested with calipers to determine its position relative to the guides and the proper adjustment made until the piston rod is the same distance from the guides at all points when the crank is on the crank-end center.

These tests should show aligning faults in the engine.

High Vacuum with Surface Condensers

By P. E. Reynolds

The article refers principally to large turbine units, 5000 kw., or over, used with surface condensers having separate hot-well and dry-vacuum pumps, although much of it applies to condenser practice in general.

With vacuums* between 27 and 29 in. of mercury on large turbines it has been determined by tests that 0.1 in. increase in vacuum corresponds approximately to 0.1 lb. decrease in steam consumption per kilowatt-hour, so that a turbine operating with 27 in. of vacuum and having a consumption of 15.5 lb. of steam per kilowatt-hour would reduce its consumption to 14.5 lb. if the vacuum were raised to 28 in. Figuring the cost of generating 1000 lb. of steam at $0.20, this gain in vacuum would mean a saving of approximately $1.75 per kilowatt per year or for a 10,000-kw. output a saving of $17,500 per year.

Just what would be considered a good vacuum depends on the design of the condenser apparatus in question and the supply and temperature of cooling water available. Most surface condensers are calculated to condense from 6 to 8 lb. of steam per hour per square foot of cooling surface, so that an 8000-kw. turbine using a maximum of 150,000 lb. of steam per hour would require a condenser having about 20,000 sq.ft. of cooling surface. Sufficient cooling water should be available to keep the temperature of the circulating water discharge below 90 deg. F., and the dry-vacuum pump should have a volumetric capacity of at least 30 times the volume of the condensed steam. Under these conditions a vacuum above 28 in. of mercury would be considered good. However, nothing but the highest vacuum obtainable with the apparatus at hand in the best of operating condition should be considered satisfactory.

Naturally the highest vacuum obtainable with any given condensing outfit is limited by its design and the amount and temperature of the cooling water, but there are many items affecting the maintenance of a high vacuum which come entirely within the control of the operating engineer and require careful attention. The most important of these items are:

Leakage of outside air into the condenser.

Dirty condenser tubes and accumulations of trash on the tube sheets which would restrict the flow of circulating water.

The condition of the dry-vacuum pump air cylinder and valves.

The condition of the circulating pump.

To locate the cause of low vacuums it is necessary to install thermometers at the hotwell, at the circulating-water inlet and outlet and on the air suction to the dry-vacuum pump. A mercury column or gage, preferably the former, should be connected to the top and the bottom of the condenser to give the vacuum, and all readings should be corrected to a 30-in. barometer for comparison. Whenever possible a thermometer should be installed to give the temperature of the turbine exhaust steam, as this temperature can be used as a check on the mercury column. All the thermometers mentioned should be installed in permanent form for use in regulating the regular operation of the condenser as well as in determining troubles.

Fig. 1 shows a general turbine and condenser installation and indicates the positions for the various thermometer and mercury-column connections. One column may be connected as shown to measure the vacuum both at the top and the bottom of the condenser.

If the cause of poor vacuum is insufficient cooling water, it will be shown by the high temperature of the circulating-water discharge. With a constant load on the turbine this temperature is controlled by the inlet temperature and the amount of water used. Since the inlet temperature is not under control the only way to lower the discharge temperature is to increase the amount of cooling water. This may be done by overhauling the circulating pump and by making sure that the suction and discharge pipes and the tube sheets are clear of trash or any obstruction which might restrict the flow.

An approximate formula for calculating the amount of circulating water required is as follows:

Assume 1000 equals the latent heat of steam in B.t.u. at 1 lb. abs. times its quality plus the difference in temperature between the hotwell water and the tem-

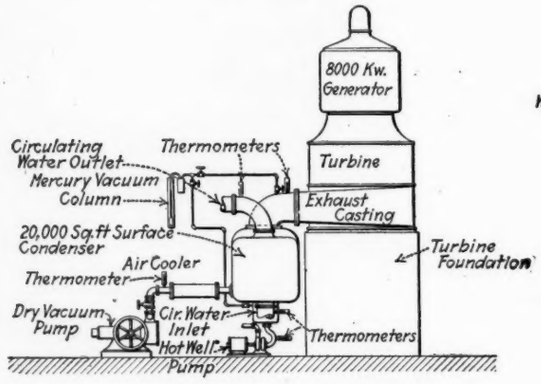


FIG. 1. LOCATION OF THERMOMETERS

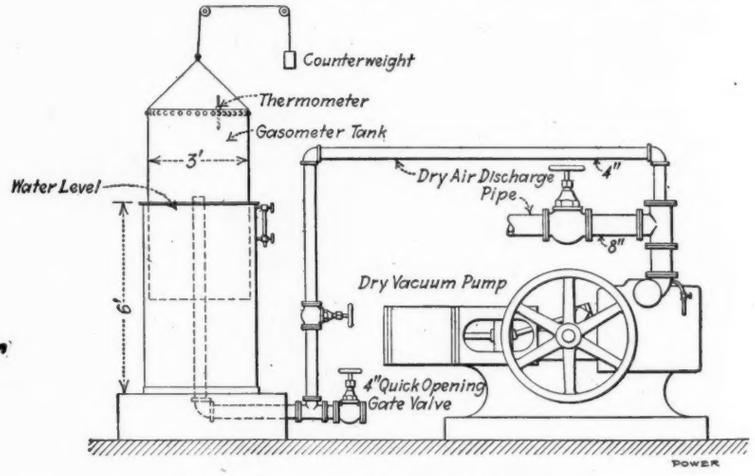


FIG. 2. GASOMETER TANK FOR METERING AIR

*All vacuums are referred to a 30-in. barometer.

perature of the steam corresponding to its pressure, then

$$(A \times 8.33 \times 60)(t_o - t_i) = 1000\,S$$
$$A\,(t_o - t_i) = 2\,S$$

where

A = Circulating water in gal. per min.;
t_i = Inlet temperature of water, deg. F.;
t_o = Outlet temperature of water, deg. F.;
S = Condensed steam in lb. per hr.

To solve for A transpose the above equation to

$$A = \frac{2\,S}{t_o - t_i}$$

or if t_i, S and A are known, it may be made to read

$$t_o = \frac{2\,S + A\,t_i}{A}$$

This equation shows that with the load S remaining constant, the temperature of the circulating-water discharge t_o depends entirely on the inlet temperature t_i and the flow A, and is independent of the vacuum maintained.

Another cause of low vacuum may be air leakage at the valves and piston of the dry-vacuum pump. To determine if such is the case the pump should be tested at a time when the turbine is not in use by closing the valve in the air-suction line and noting the vacuum obtained when operating the pump at its normal speed. Under these conditions a pump for high-vacuum work should produce a vacuum of within 0.4 or 0.5 in. of mercury of the height of the barometer. If the pump does not produce this vacuum, a general overhauling or repacking and tightening of the glands may produce the desired result. It may also be possible that the air cylinder and valve are not being properly lubricated and cooled.

Probably the most prevalent cause of poor vacuum is air leakage into the condenser. This may happen at any of the numerous connections and joints in the condenser or vacuum stages of the turbine. The table following gives the results of a test made on a 10,000-kw. unit to determine the effect of different sized air leaks on the vacuum obtained. Air was let into the condenser near the top through various sized orifices in flat disks and no readings were taken until after the vacuum had become constant.

Size of orifice, in.....	0	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$
Load on gen. kw.....	9000	9000	9000	9000
Vacuum at top of condenser—corr. to 30 in. barometer.....	28.90	28.88	28.72	28.51
Size of orifice, in.....	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$
Load on gen. kw.....	9000	9000	9000	9000
Vacuum at top of condenser—corr. to 30 in. barometer.....	28.31	27.96	27.74	27.30

It may be seen that leaks aggregating the area of a $\frac{5}{16}$-in. hole will cause a drop of 1 in. in vacuum and increase the cost of operating a turbine of this size by nearly $50 per day.

To test for air leaks the condenser and lower stages of the turbine should be filled up with warm water and all joints showing leakage carefully tightened and then given a heavy coat of asphalt paint or shellac. The water should be warm to reduce the strains caused by cooling and prevent the forming of condensate or sweat on the outside, as the latter might preclude the possibility of finding small leaks. The use of a candle flame is unsatisfactory, especially if there are drafts around the condenser. It may be possible that the condenser castings are porous or contain minute cracks. For this reason the complete surface under vacuum should be carefully examined and given a good coat of paint. Considerable air leakage may also occur at the seals where the main turbine shaft leaves the casing. Care should be taken to have sufficient pressure, either steam or water, at these points to prevent any possibility of air leaking into the condenser.

It has been determined by numerous tests in plants using open heaters and where a good part of the feed water is returned from surface condensers that the amount of air carried into the condenser with the exhaust steam is too small to appreciably affect the vacuum, the bulk of air coming in through leaks in the shell. It is evident that to maintain a constant vacuum this air must be removed by the dry-vacuum pump at the same rate at which it leaks in. Otherwise it would accumulate and the condenser become air-bound.

To determine the rate of air leakage it is only necessary to measure the air discharged by the dry-vacuum pump. A method for doing this, which has been tried by the writer and found very successful, is to meter the air in a gasometer tank, as shown in Fig. 2. The air is discharged by the dry-vacuum pump into an inverted cylindrical tank which is sealed with water at the bottom and balanced with a counterweight. This tank rises as air is discharged into it, so by timing any definite rise of the tank and knowing the corresponding volume, the leakage into the condenser can be calculated in cubic feet per minute at atmospheric pressure. A gasometer tank 3 ft. in diameter and 6 ft. high and capable of measuring 30 cu.ft. per min. is large enough for ordinary condenser work. The gasometer method of determining air leakage is simple, accurate and inexpensive and requires only a few minutes for its operation.

To obtain a good vacuum the leakage should be kept below 20 cu.ft. of atmospheric air per minute, which can easily be accomplished by careful attention.

Crucible steel was first successfully produced in the United States in 1832 at the works of William and John H. Garrard, at Cincinnati, Ohio.

Economic Riddance of Turbine Scale

By Morgan G. Johns

In a certain generating station operating about 65,000 kw. of turbines great difficulty was experienced by having the wheel vanes, or buckets as they are commonly called, constantly fill up with a hard scale deposited from the river water used in the boilers. With the increased obstruction to the passage of the steam the stage pressure would increase at a rapid rate, making it necessary to take a side out of each turbine about once every four or five months, and in the spring, when the freshets would bring down the refuse from up the river, the vanes would have to be cleaned as often as every three weeks. This was expensive, costing approximately $80 per turbine every time it was undertaken.

A sample of the deposit cut from the vanes with a cold chisel was taken to a chemist for analysis with the intention of arriving at some substance which could be put in the feed water as a boiler compound to counteract the scale producer and bring it down as a precipitate in the boiler. In this way fairly good results were obtained.

One day as the writer was passing a machine being cleaned, he stopped to talk with the foreman in charge and asked the nature of the substance he was using to partly loosen the scale before using the chisels, and was told that it was coal oil. Immediately the idea was conceived of pumping the oil in with the steam just as it entered the turbine and in that way cut the scale out without dismantling the machine or even taking it off the line.

To do this the load on the turbine was reduced to about one-tenth of normal and the vacuum pump was stopped, the free exhaust valve opened and the turbine thrown over on high pressure. About six barrels of coal oil were then pumped into the steam line just in front of the admission valves on the running side by a small triplex motor-driven pump. The time consumed was about one hour, after which the pump was stopped, the condenser pump gradually started up until the vacuum had picked up enough to close the free exhaust valve, and when normal conditions were reached the load was again put on the machine.

With coal oil selling at $3.50 a barrel, the cleaning cost $21 as against $80 by the old method, and without having taken the machine out of commission for one minute of the time.

To make sure that this method was having no ill effect on the vanes, a side was taken out of one of the machines which had just been washed. The scale had been entirely removed from both the guide and wheel vanes, leaving them absolutely smooth and highly polished.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

The operation of ordinary pump valves are explained, why a pump operates with a shock at the end of the stroke, and how cut-off valves prevent the evil

It is strange how unusual experiences will disturb one's rest at night. I found it so, for, after bidding Hunter good night upon our return from visiting the mine pumps, I tumbled into bed to dream of gigantic pumps working to free a small chamber of water, in which I was imprisoned. The pumps were unable to keep the water down and I soon found myself climbing up the perpendicular walls in an endeavor to escape, but slipping, plunged into the black, surging, gurgling water with a splash. Ugh! it was cold. Then I awoke and found that my cold plunge was the result of wind and rain blowing upon me through an open window.

Morning finally came, but not before I had escaped death in a dozen ways from one danger or another. After a cold plunge and a good breakfast, I boarded the first street car that came along, determined to go to the end of the line, wherever that might be, and as the rain of the night before had clarified the atmosphere, it was most enjoyable.

When the car stopped and the conductor shouted "All out!" I found myself within a stone's throw of No. 2 shaft of the Susquehanna Coal Co. Stifling any fears of possible explosions and flooding mines I began to hunt for Superintendent Koalbreaker, who, the men about the mine said, "would be difficult to locate, as he was all over the lot and didn't wear out his clothing very much holding down the office chairs. But when you find him he will talk with you."

One man had seen Mr. Koalbreaker headed for a culm pile about a mile distant from the shaft. Jumping on one of the small locomotives that was going that way, I eventually located him, and, after stating my errand, how I would like to examine his underground pump rooms, was told to go as far as I liked. He turned me over to Master Mechanic Morgan, who introduced me to a fireboss and we were soon 600 ft. under ground.

The first pump room visited was close to the foot of the shaft; it is shown in Fig. 1. The construction of the walls and roof was different from what I had before seen. The walls were of concrete to a height of about 5 ft. with I-beams imbedded in the concrete at the bottom end, and supporting heavy I-beams at the top which held the ceiling in place. The side walls were built up above the concrete with discarded 3-in. pipe lengths; the ceiling was lined with discarded 6-in. sump pipe. The space back of and above the pipe was filled in with earth. The interior of the pump room was painted white and the floor was of cement. As I had expected to see something far different, the equipment and surroundings impressed me with their neat appearance.

We were given a welcome by the pump men, even the cat on the upper rung of the ladder, a favorite resting place, I was told, seemed pleased to see us.

The compound, duplex, outside-packed Goyne pump was running, pumping 2400 gal. of water per min. against a head of 608 ft., which included the suction lift.

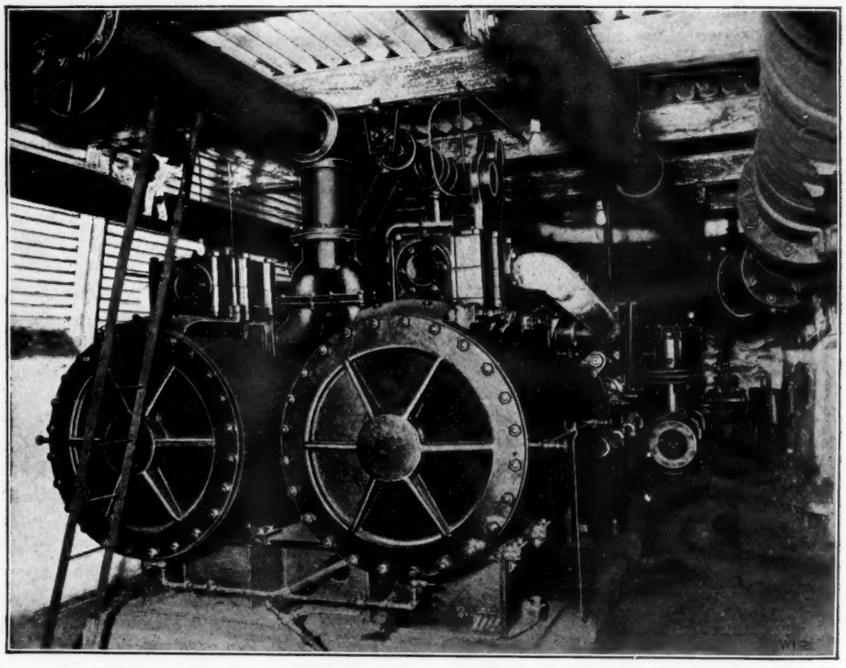


FIG. 1. GOYNE STEAM PUMP AT NO. 2 SUSQUEHANNA COLLIERY

The steam cylinders were 23 and 40 in. and the water cylinders 40 in. in diameter, and 48-in stroke. A perspective view of the pump is shown in Fig. 2.

I found what I was told was a new kind of valve-gear in that, besides the usual type of slide valve common to duplex direct-acting pumps, there were also adjustable cutoff valves. These were not for the purpose of using steam expansively at all speeds, but to obtain economy in steam consumption when running at slow speed or at speeds considerably below normal, also to obtain quick operation without shock and jar when running at high speed.

While examining the pump, several men stopped at the entrance to the pump room and turning, I saw Hunter was one of the party. Having finished his business with his companions, he suggested that he accompany me to act as a sort of guardian angel, to which I gladly assented.

"Know anything about the valve action on this pump?" I asked.

"I think so," replied Hunter. "It is like this, with a duplex pump the steam valves on one side of the pump are operated by the movement of the piston on the opposite side, and *vice versa,* by intervening mechanism by which each piston in its stroke movement reverses the valve on the opposite side, which releases the exhaust steam from one end of one cylinder and admits steam to the other end of the opposite cylinder. Neither piston movement cuts off the admission of steam, which follows the piston full volume with the valve wide open up to the end of the stroke.

"The stroke is ended by the piston covering the exhaust outlet near the end of the cylinder, entrapping the remaining steam, after which a slightly further forward movement of the piston compresses the steam so that the piston is brought to a stop before striking the cylinder head."

"Makes a sort of cushion," said I.

"Exactly; but when the piston has made approximately three-fourths of its stroke, its movement has reversed the valve on the opposite steam cylinder and its piston begins its stroke. The relative

positions of the pistons are such that by the time the one that has made three-fourths of a stroke reaches the end of its travel, the other piston will have made one-fourth of its stroke and will have the second and third fourth of its stroke to make before it reverses the valve that starts the piston that has been at rest against its cushion on its return stroke.

"Now, here is something for you to remember. During the time the piston is resting on a steam cushion, about one-

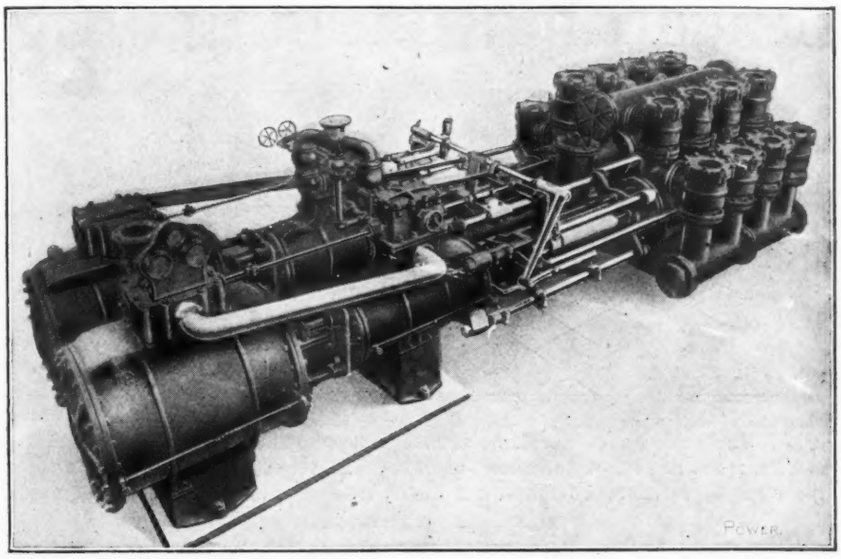


FIG. 2. PERSPECTIVE VIEW OF THE GOYNE STEAM PUMP

half the time, the steam-chest admission valve has been wide open, and as the throttle valve between the steam line and each steam cylinder is wide open, the direct-acting pump must have a considerable power margin to meet the varying conditions, particularly in mine work. In the average case, there is a large difference in the main steam-line pressure and the required cylinder pressure to overcome the water-end resistance."

"Yes, you explained that clearly only yesterday. It looks to me as though there might be considerable cylinder condensation."

"Sure, for during the time the steam pistons are at rest, at the end of the stroke, all of the steam that flows uninterrupted from the high-pressure steam pipe into the steam of less density in the steam cylinder is wasted as the pump cannot return any work. If a cutoff were arranged and used, better economy would be obtained."

"Well, how does this cutoff take place?" I inquired, watching the cat frisking with a piece of waste.

"When steam is admitted to the steam cylinder by the movement of the opposite piston, the cutoff is operated by the movement of the piston of the cylinders to which it is applied and controlled, and is adjusted by turning a handwheel to suit the speed at which the pump runs. The cutoff takes place, depending on the speed, just as the piston reaches the end of its fixed stroke or at any point earlier up to within 7 in. of the end of the stroke, which is enough for the highest speed, because in direct-acting pumps there is no flywheel in which to store up power that can be utilized in completing the stroke after steam has been cut off. And the only available power for the purpose is the momentum of the moving parts of the pump, and the moving column of water. It has been found in practice that these are enough with pumps running at high speed, even when working against heavy pumping heads, to complete the last 6 in. of the stroke with the steam cut off entirely."

"From what you have just said, the advantage acquired with the adjustable cutoff in the last 7 in. of the stroke and its resulting economy are obtainable only when running at high speed."

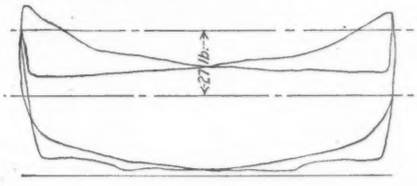


FIG. 3. DIAGRAM OF PUMP OPERATED WITHOUT THE CUTOFF ATTACHMENT

"Yes, that is right, and the economy gained by expansion is only secondary to the economy gained in slow and normal speed operation by preventing the equalization of the high steam pressure in the supply pipe and the low steam pressure in the steam cylinders after the pistons have completed their stroke, and are resting on their steam cushions where they can give up no work.

"In slow running, the cutoffs are adjusted so that steam is cut off just before the ending of the stroke.

"There were some tests run to obtain a comparison of the steam consumption calculated from indicator diagrams and speed of pumps combined with smooth running with and without the cutoff attachment and controlled by the main valve and with the supplementary valve in each case."

Hunter at this point pulled out his ever-ready notebook and, after referring to its pages, said, "The piston speed obtained without excessive shock and without cutoff was 126, and with cutoff, 153 ft. per min. for each piston. Under these conditions the steam consumption per indicated horsepower per hour was 57.05 lb. without and 38.7 lb. with cutoff."

"Why should cutoff adjustment cause the pump to operate without shock or jar? Just tell me that," I demanded.

"Easiest thing in the world," replied Hunter. "In a duplex direct-acting steam pump, the steam-admission valve is moved wide open at the beginning of the stroke and is not closed, nor can it be closed, to cause the end of the piston stroke, which is accomplished by the action of a steam cushion, as I have already told you, by entrapping the exhaust steam in approximately the last inch of the stroke. This brings a heavy mass of moving parts from full speed to a dead stop in a second's time usually with a slam.

"In a small pump this does not cause much inconvenience as the parts are of light weight, neither would it be noticed much in large pumps running at normal speed. But pumps used in pumping mine water are frequently required to operate at speeds beyond their maximum rating and could safely do so were it not for the shock at the end of the stroke caused by the abrupt stop, and there is danger of accidents when operating to any considerable extent above normal speed."

"Yes, you told me that before. But

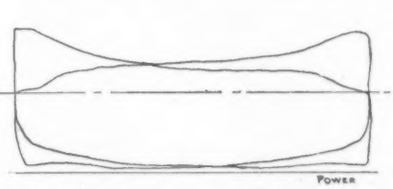


FIG. 4. DIAGRAM OF PUMP OPERATING WITH THE CUTOFF ATTACHMENT

that doesn't explain why the cutoff valve removes shock."

"Gee, but you are like an old woman; you ask questions, and before they can be answered, you kick because they aren't. Now, listen; you take the same pump and provide it with cutoff valves. After each piston has made about two-thirds stroke, the cutoff valves begin to close, gradually reducing the volume of steam flowing into the cylinder and even

though the mean piston velocity is far in excess of the maximum rating, its progress is retarded by the adjustment of the cutoff to correspond with the increased speed that will cause an early and quiet ending of the stroke without the slightest shock, because the velocity of the piston is retarded before it is brought to a sudden stop by the compressed steam."

Hunter detached a loose leaf from his notebook on which were two diagrams, Figs. 3 and 4, taken from the pump under discussion.

"When the pump was running without the cutoff, the greatest steam economy was obtained when the pump was controlled by the main throttle valves. When the pump was running with cutoff the greatest steam economy was obtained while the pump was controlled by the supplementary throttle valves." He drew a dotted line through the two diagrams, remarking as he did so: "This dotted line shows the relative steam economy of the two conditions of pumping, the two diagrams being taken with the same piston speed and with the pump working against the same head, one using 40, the other 64.8 lb. of steam per indicated horsepower."

Just then the cat made a jump for a rat and further conversation was dropped for the time being, due to the excitement of the chase which resulted in the rat escaping in the black depths of the mine.

Design of Indicator Reducing Rigs

By A. L. Westcott

The author describes several types of indicator reducing motions he has operated with different steam engines, an air compressor and gas engine.

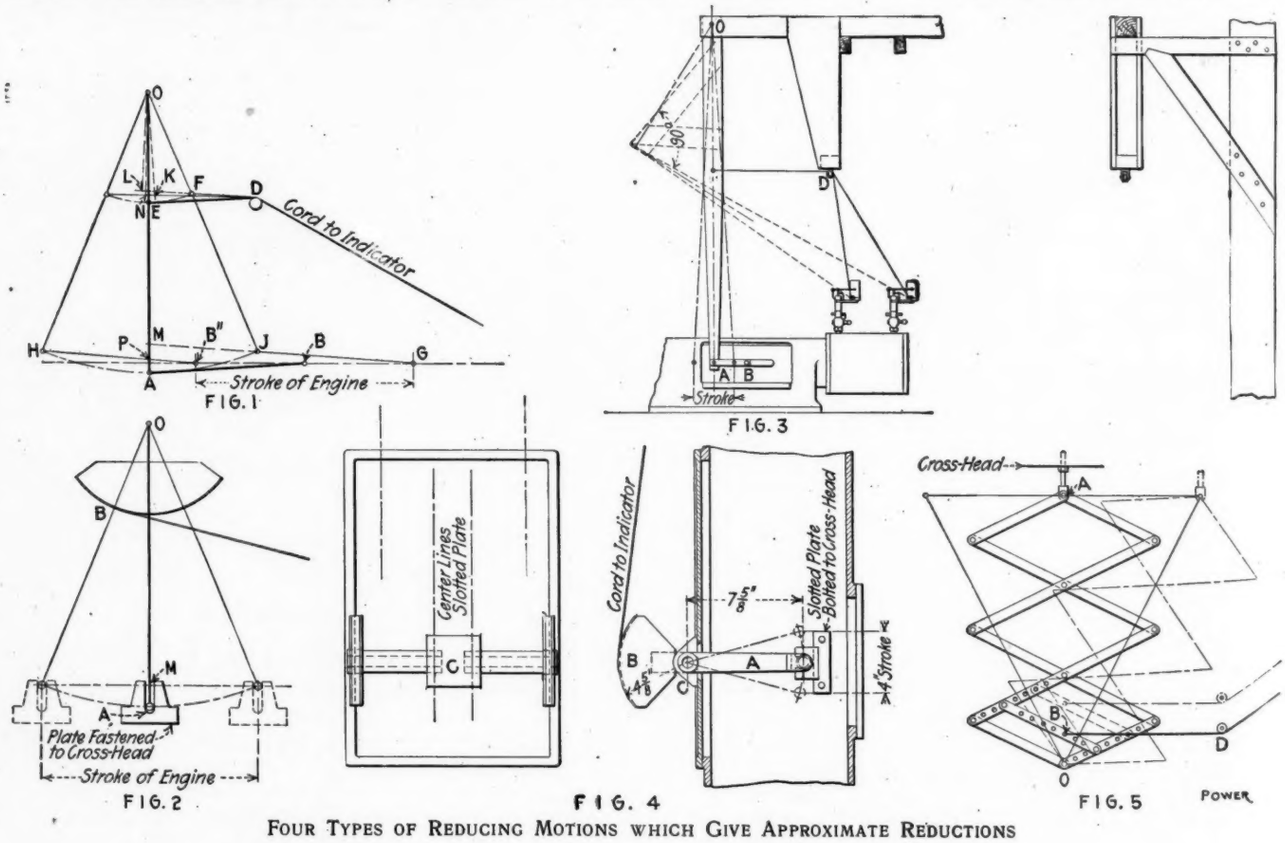
In selecting a reducing rig for a given engine, numerous considerations should be taken into account. A rig suitable for a long-stroke, slow-speed engine may be unsuitable for a high-speed short-stroke engine and the resulting large inertia of moving parts.

Indicator-reducing rigs may be divided into two classes based on geometrical design, those which produce correct reductions and those which approximately do so. Figs. 1 to 4 belong to the approximate classification, and Figs. 5 to 8 represent the correct forms.

Fig. 1 indicates a rig of the pendulum form, arranged for use on a horizontal engine. The swinging arm *OA* is connected by a link *AB* to a pin *B* on the crosshead. A cord attached to a pin *E* leads over a guide pulley *D* to the indicator. The guide pulley should be so located that the line *ED* is horizontal, or, if the distance is short, so that the horizontal line tangent to *D* bisects the versine of the angle *EOF*. The position of the pivot *O* should be such that the link *AB* swings equally above and below the horizontal line, and the swing on each side of the vertical line *OA* should be equal, making the angles *JOA* and *AOH* equal.

The degree of accuracy of this rig may be determined by the following considerations. Produce the line of the link in any position, as *JG*, until it intersects the vertical center line *OA*, at some point as *M*. The relative velocities at points *A* and *B* are as the ratio of the radial distances *OA* and *OM*. The distance *OM* varies with the position of *B*, between the extreme values of *OM* and *OA*.

The velocity of the drum cord is proportional to the length of the perpendicular let fall from *O* upon the line of the cord. If the length of the pendulum *OA*, represents to scale the velocity of the



FOUR TYPES OF REDUCING MOTIONS WHICH GIVE APPROXIMATE REDUCTIONS

point A in any position, then to the same scale the perpendiculars OK, OL, etc., represent the corresponding velocities of the drum cord. The ratio of the velocities of drum cord and crosshead, then is given by the expression

$$\frac{OL}{OA} \times \frac{OA}{OM} = \frac{OL}{OM}$$

for the position of the pendulum OF. Similarly, for the position OA, the ratio is $\frac{OK}{OA}$, etc. With the mechanism proportioned as shown, the values of this

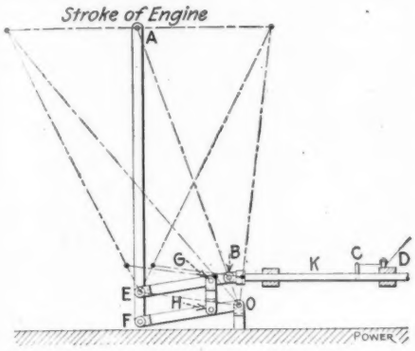


FIG. 6. MODIFICATION OF PANTOGRAPH

ratio in the two extreme and the mid positions are as follows:

$$\frac{OL}{OM} = 0.389$$

$$\frac{OL}{OA} = 0.395$$

$$\frac{ON}{OP} = 0.388$$

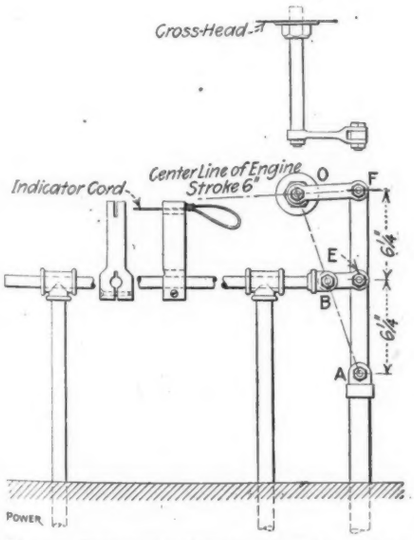


FIG. 7. REDUCING MOTION FOR AIR COMPRESSORS

The stretching of the cord by the inertia of the drum may cause some appreciable error at high speeds. And this is increased because the cord is deflected over a guide pulley. At high speeds it is preferable to so arrange, where possible, that the cord leads directly to the indicator without change of direction.

This may be accomplished by substituting the brumbo pulley, which is a circular segment, whose center is at O. The cord may lead off tangent to this in any direction, as in Fig. 2. With this modification, the length of the perpendicular OK, Fig. 1, let fall from O upon the line of the cord, becomes constant for all positions. The variation in velocity ratio of the cord to the crosshead is thus increased, the values for the three positions becoming 0.438, 0.395 and 0.418, respectively. The sacrifice of theoretical accuracy may be offset by the gain, due to the decrease in cord tension.

Fig. 3 shows a rig constructed for a 6x8-in. high-speed engine. It is intended as an example for students in the construction of an inexpensive rig for temporary use. With these proportions of swinging arm to the stroke of the engine the motion is practically exact. An improvement in the device by which the cord could be led in a straight line to the indicator, is indicated by dotted lines.

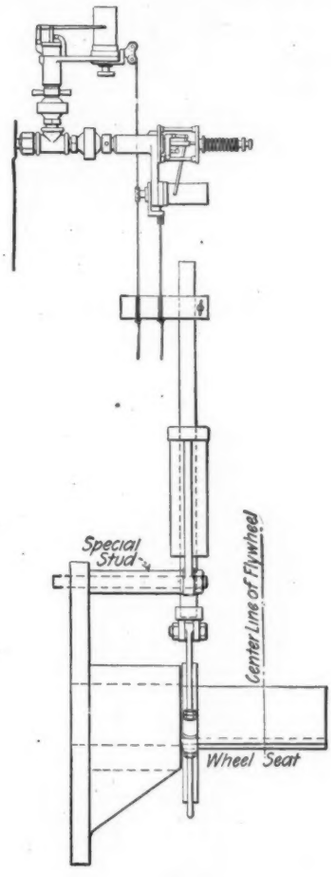


Fig. 2 shows a modification of the pendulum form adapted to high speeds. Besides the brumbo pulley, the swinging arm is driven at A, by a slotted plate attached to the crosshead; the center line of the slot is perpendicular to the stroke of the engine. The velocity ratio of the pin A, to the crosshead for any position is determined by drawing a line through the center of the pin perpendicular to OA, and noting its intersection with OA. The length of this intercept from O represents the velocity of the crosshead to the same scale that OA represents the velocity of the pin.

At the ends of the stroke, the ratio is $OA : OM$. At mid-stroke it is equal to unity. The ratio of cord velocity to that of the crosshead is, therefore, $OB : OM$ at the ends of the stroke, and $OB : OA$ at the center, its value varying between these two limits. With the same proportion of arm radius to the stroke of the engine, this form is more exact than the combination of brumbo pulley and link AB, shown in Fig. 1.

Fig. 4 shows a rig of slotted plate and brumbo pulley combination designed for a small vertical, compound engine with an inclosed crank case. With the proportions chosen, the error is very small. A roller, mounted upon a pin passing through the forked end of the lever arm A is actuated by the two sides of the slot in the plate. It has the advantage of lightness and a small number of moving parts, which is important when dealing with speeds of over 400 r.p.m. The splash system of lubrication employed oils all pins and bearings, and a cover C, of sheet metal, over the spindle bearings catches oil that splashes through the opening in the cover plate and drains it back into the crank case.

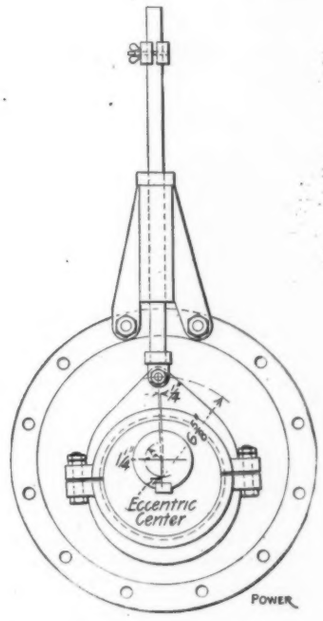


FIG. 8. REDUCING MOTION FOR GAS ENGINE

For long-stroke low-speed engines, a form of the pantograph shown in Fig. 5 is used, where the lengths of stroke of various engines varies from 30 to 60 in. The point O is fixed, but A is attached by a pin connection to the cross-

head. To give a correct motion, the pin *B*, to which the cord is attached, must lie on a line with *O* and *A*, and the cord *BD* must lead off parallel to the stroke of the engine. The ratio of the length of the indicator diagram to the length of the stroke will then be equal to *OB*: *OA*. Means are provided for changing the position of *B* by moving the cross-bar, as indicated by the dotted lines, so that in working on engines of different stroke, the lengths of indicator diagrams can be kept approximately constant.

Figs. 6 and 7 are modifications of the pantograph, and built for a permanent fixture on a single engine. In Fig. 6 the point *A* is attached to the crosshead, and is disconnected when not in use. The essential conditions to give a correct reduction of the piston motion are that the point *B* must be on the line *OA*, the link *OF* must be parallel to *BE* and *GH* parallel to *AF*. The point *B* moves in a straight line parallel to the path of *A*. The sliding rod *K*, to which the motion of *B* is transmitted, is guided by supporting bearings and is long enough to reach both cylinders of a tandem-compound engine, so that the indicator cord connections may be short. The cord is guided over a pulley, so that *CD* is parallel to the motion of *K*.

The rig shown in Fig. 7 was designed for an air compressor of 6-in. stroke. The point *O* in this case is attached to the crosshead and *A* is the fixed point, but the character of the movement is the same. As in Fig. 6, *OF* must be parallel to *BE*, and the point *B* must be on the straight line *OA*. The link *GH*, Fig. 6, is omitted, as the sliding rod is guided by bearings and the stroke is short, so that the maximum angle of *BE* with the center line of the rod is small. The compressor speed is 150 to 200 r.p.m., and to avoid carrying the indicator cords over guide pulleys, wooden brackets were made and clamped on the sliding rod. The method of attaching and detaching the cord to the bracket is shown.

The purchase of a gas engine brought the problem of a suitable reducing rig. The engine was of the two-cylinder, vertical, inclosed-crank case type. Fig. 8 shows the design of reducing rig that was adopted. The flywheel was removed, and an eccentric set on the shaft next to the main bearing, with the eccentric and crank angles coinciding. The eccentric strap was attached by a pin connection to a drawn-steel tube slide, guided by a babbitt-lined bearing. Two long studs replaced two of the cap bolts which held the end housing to the frame of the engine, and these support the guide casting. A wooden bracket, clamped to the slide tube, and slotted at the proper radial distance was used to attach the indicator cords.

Two indicators were used, one with a stiff spring for high-pressure diagrams, and one with a weak spring and stop, for taking the exhaust and intake lines. The former was set in a horizontal position with a very short direct drum-cord connection. The cord of the weak-spring instrument made a right-angle bend between the bracket and the drum. As the work represented by the weak-spring diagram is but a small per cent. of the total work, any slight error from this cause was considered negligible. The mechanism was designed to exactly reproduce the motion of the engine piston. Thus, the radius of the engine crank being 5 in., and the length of the connecting-rod 26½ in., and it being desired to obtain a diagram 2½ in. long, the eccentric radius was made 1¼ in., and the length of the eccentric strap was made one-fourth of 26½, or 6⅝ in. As the center line of the engine cylinders is 1 in. in front of the vertical center line through the crankshaft, the center line of the slider was set ¼ in. forward. This arrangement gave an exact reproduction, on a reduced scale, of the motion of the engine piston.

Derrick Hoist Safety Devices

By R. Reddie

Two of the most prolific causes of injury and death to the operator of a derrick-hoist are a fall when climbing the back-leg to oil the mast-head pin; or being hit by the loose end of a broken rope as it comes lashing into the engine house.

Fig. 1 shows a black-oil force-feed oiler which is attached at the ground level to a back-leg of a derrick. A ¼-in. pipe leads up the back-leg to the mast-head and is held in place thereon by spikes, as shown. The oiler is filled through the plug cock by running the plunger back above the top level. The ¼-in. globe valve is kept closed except when forcing oil to the mast-head.

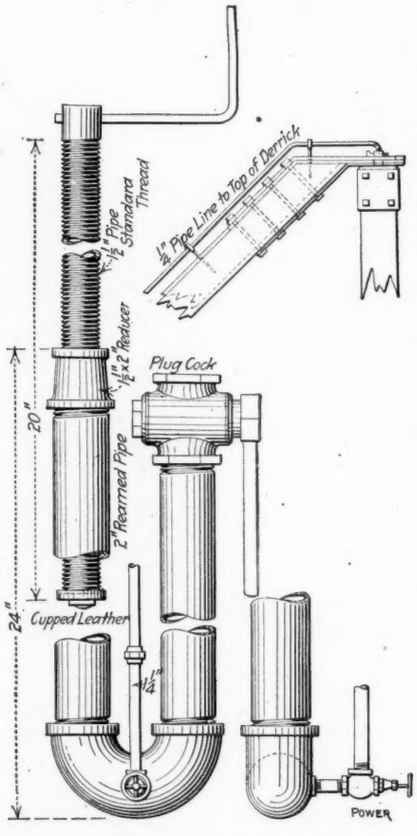


Fig. 1. Masthead Oiler

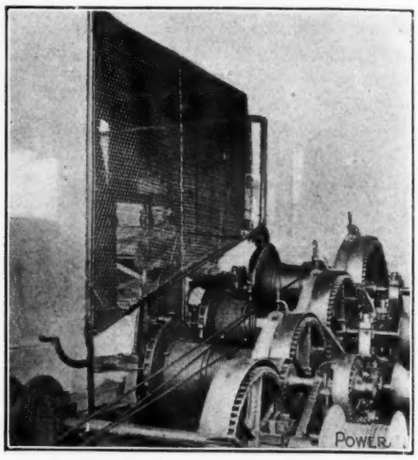


Fig. 2. Engine Room Screen

Fig. 2 shows a screen between the engineer and the drums of his engine, and is self-explanatory.

Steam Boiler Furnace Design

The design of special furnaces suited to local fuel conditions has been neglected until recently. The downtown district of Chicago was built largely during the early nineties and prior to 1900 contained perhaps not a furnace suitable for the proper combustion of Western fuels. Marked developments have been made and suitable furnaces are now built.

Anthracite coal contains from 3 to 10 per cent. of volatile matter and burns with a clear flame 1 or 2 ft. long for a few seconds after firing, after which the bed of hot carbon remains active and complete combustion is obtained. A furnace having a length or height of only 2 or 3 ft. is ample with such fuel; the main object is to insure sufficient and uniform air supply. A deficiency of air can exist with such fuels without producing smoke, but not without loss in economy. The most approved furnaces for this service have flat or slightly inclined grates, the boilers are set between 2 and 3 ft. above the grate surface, 4 or 5 ft. above the floor level and the air is supplied by a mechanical-draft system. Ten years ago these dimensions and proportions were given as standards and little or no consideration was given to fuels. It was also believed that smokeless stacks could

be obtained only by burning anthracite coal.

For semibituminous fuels containing from 8 to 25 per cent. of volatile matter, more ample furnace space must be allowed. These fuels have a large amount of hydrocarbons which, under heat, are liberated and, being long flaming gases, require a large chamber in which complete combustion can occur and sufficient air at high temperature can be mixed with the gases. This cannot obtain in the anthracite furnace and if such coals are used, unconsumed hydrocarbons, or smoke, will result.

The fuels of the Pittsburgh district border between coking and free burning coals. They are relatively low in smoking volatiles and do not require the extreme treatment of the Middle Western coals, but require a larger combustion chamber and a longer time for combustion to take place than the semibituminous coals.

In the Middle West the free burning coals, particularly well adapted to chain grates, contain from 25 to 40 per cent. of volatile matter and are difficult to handle from the standpoint of economical and smokeless combustion.

The length of flame given off from the high volatile Western coals is from 15 to 20 ft. and to prevent loss in economy, and also objectionable smoke, the flame should not enter a region capable of extinguishing combustion until it has traveled at least 10 ft. in a chamber surrounded by incandescent firebrick and having suitable mixing devices, causing the air to mingle intimately with the hydrocarbons.

With the vertically baffled boiler a suitable furnace is obtained by setting the boiler 8 ft. 6 in. high under the front header, and applying a dutch-oven furnace 6 ft. long. This permits a setting with an ignition arch 5 ft. long and a secondary arch at a higher elevation of the same length. The mixing effect, produced by the offset between these two arches, does much to complete combustion and prolong the interval while the gases pass between the fuel bed and boiler-heating surface.

The furnaces used with vertical boilers, for structural reasons, need an extensive arch construction which necessitates a "throat" over the bridge-wall which must be large unless unusual draft pressures are provided. The action of this furnace is similar to that of a horizontal water-tube boiler except that it tends to make the brickwork of the side walls hotter near the inspection door. This furnace is difficult to keep in repair, because all accumulation on the bridge-wall reduces the area of the furnace throat. Such a furnace is not well designed unless amply providing for cleaning the bridge-wall and front bank of tubes. A net area of 30 per cent. of the grate area should be allowed at this section.

The horizontally baffled boiler with tube tile on the lower row of tubes, provides a furnace roof easily constructed and repaired, and producing practically the same effect as an arch-constructed roof. With an ignition arch 5 ft. long, and the boiler set 7 ft. from the header to the floor, a simple furnace design is possible with a 42-in. projection in front of the boiler fronts. Combustion is perhaps carried out to its most complete stages in this furnace and the true furnace efficiency is usually very high.

Good results can be obtained at uniform rates of firing with a return-tubular boiler having an ignition arch only 4 ft. long. However, the boiler shell is a poor substitute for a tile roof for prolonging combustion, and a checking of this action results, usually indicated by No. 2 smoke which with variable loads becomes No. 3. This boiler should have a setting such as is used for vertically baffled boilers.

The furnaces mentioned herein are those to be considered where standard chain grates are used, burning standard coals at rates up to 30 lb. per square foot of grate surface per hour. Often the fuel requires special treatment or higher combustion rates are desired.

For higher combustion rates, the best furnace would have a horizontal arch 12 to 18 in. above the grate surface, and 6 to 8 ft. long, the greater height going with the longer arch, and both being desirable for high-ash coals and extra-long grate surfaces. The feature of such an arch is that there is virtually a 50 per cent. reduction in the draft pressure from the front to the rear or from the inspection door to the front of the arch. In other words, with 0.50-in. draft pressure through the inspection door only 0.25 in. would be obtained at the front of the arch. From this it is evident that such a furnace cannot be successfully used where the draft is only 0.20 to 0.30 in., as the reduction would result in a draft so low that combustion could not be sustained at the ignition point of the fuel.

Conversely the 0.50-in. draft could not be successfully used with the arch furnace setting as the reduction of draft is only about 10 per cent. and the resultant draft pressure would be too great at the point of ignition, and permit too much unnecessary air to enter the furnace, cooling the arch and reducing the combustion rate to below 30 lb. per square foot per hour. This capacity furnace is well adapted to coals having 20 per cent. or more of ash as high boiler ratings are so difficult to obtain with the usual grate sizes that high combustion rates are made necessary.

Coals tending to coke and cake should be treated somewhat similarly if used on chain grates. It is possible to coke such coals in a zone of relatively low draft, and then bring them into a small section of high draft and burn them fairly well.

The object of this article is merely to present for consideration, some common types of furnaces and the reasons for their design. Structural considerations and cost of floor space often prevent the most approved furnace design, but the fact is becoming more universally known that the boiler room is the important end of the power plant and permits of many times the variation in efficiencies that can occur in the engine or turbine room.

True Boiler Efficiency

Without the aid of an external agency heat flows from a hot body only to bodies at lower temperatures; therefore a boiler can absorb only that heat which is above the temperature of the water in it. The heat that is above the temperature of the boiler water is called the "heat available for the boiler." Heat below this temperature will not flow into the boiler and therefore is not available for it. The quantity of heat a boiler will absorb per unit of time depends almost entirely on the quantity of available heat delivered to it. Any commercial boiler absorbs only part of the available heat. The heat absorbed, expressed as a percentage of the heat available, is termed the "true boiler efficiency." This efficiency depends somewhat on the way the heat is presented to the boiler, but chiefly upon the arrangement of the boiler's heating surface. The true boiler efficiency is thus a ratio that is expressed by the equation:

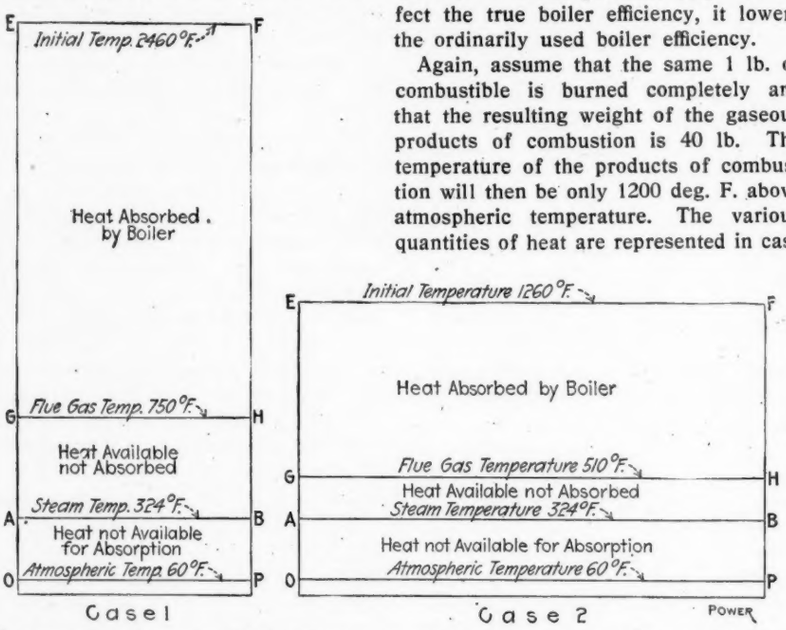
$$\textit{True boiler efficiency} = \frac{\textit{heat absorbed by boiler}}{\textit{heat available for boiler}}$$

The true boiler efficiency has been devised because it is the only true measure of the boiler's ability to absorb heat. All other boiler efficiencies used in commercial boiler tests blame the boiler for not absorbing heat that is below the temperature of the boiler water and therefore not available for absorption.

It is perhaps well to stop here and explain more fully by specific examples what the true boiler efficiency is and how it is related to the boiler efficiency ordinarily used.

Assume that 1 lb. of a combustible having a heating value of 12,000 B.t.u. is burned completely and that the gaseous products of combustion weigh 20 lb.; assume also, for simplicity, that the specific heat of the gases is 0.25; then the temperature of the products of combustion will be 2400 deg. F. above the temperature of the atmosphere. If the latter temperature is assumed to be 60 deg. F., the temperature of the products of combustion is 2460 deg. F. Then if, as in case 1 of the accompanying diagram, the results are plotted, the temperature being used as ordinates and the product of the weight of the gases multiplied by their specific heat as abscissæ, the heat generated by the burning of the combustible is repre-

sented by the area *OEFP*, the line *OP* representing the atmospheric temperature. Assume that this hot gas is passed through a boiler generating steam. If the pressure of the steam were 80 lb., the temperature of the boiler water would be about 324 deg. F. Let the line *AB* indicate this temperature. Then of the total heat generated, only the heat above 324 deg. F., or the heat represented by the area *AEFB*, is available for absorption. The remainder of the heat, represented by the area *OABP*, being below the temperature of the water in the boiler, will not flow into the water, and therefore is not available for absorption. Only the available heat represented by *AEFB* can be absorbed by an ideal boiler; therefore this heat is taken as the basis for measuring the heat-absorbing ability of a boiler.



CHARTS REPRESENTING HEAT AVAILABLE FOR ABSORPTION BY A BOILER UNDER TWO DIFFERENT TEMPERATURE CONDITIONS

Now, assume that the boiler cools the gases down to 750 deg. F. If this temperature is indicated in the diagram by the line *GH*, the heat absorbed by the boiler is represented by the area *GEFH*. Then the true boiler efficiency is shown by the ratio of the area *GEFH* to the area *AEFB;* and the ordinarily used boiler efficiency is shown by the ratio of the area *GEFH* to the area *OEFP*. The numerical values of the two efficiencies in the assumed cases are:

The true boiler efficiency,

$$E_4 = \frac{2460 - 750}{2460 - 324} = 80 \text{ per cent.}$$

Efficiency ordinarily used,

$$E = \frac{2460 - 750}{2460 - 60} = 71 \text{ per cent.}$$

If the steam, instead of being generated under 80 lb. pressure, were generated under 200 lb., the corresponding temperature of the boiler water would be 388 deg. F. On account of this higher boiler-water temperature, less heat would be available for absorption and less would be absorbed by the boiler, even though the ratios of the two heats might remain the same. If the temperature of the escaping gases assumed in the second case be 800 deg. F., the two boiler efficiencies are:

True boiler efficiency,

$$E_4 = \frac{2460 - 800}{2460 - 388} = 80 \text{ per cent.}$$

Efficiency ordinarily used,

$$E = \frac{2460 - 800}{2460 - 60} = 69 \text{ per cent.}$$

This second case shows that, although the rise in steam pressure may not affect the true boiler efficiency, it lowers the ordinarily used boiler efficiency.

Again, assume that the same 1 lb. of combustible is burned completely and that the resulting weight of the gaseous products of combustion is 40 lb. The temperature of the products of combustion will then be only 1200 deg. F. above atmospheric temperature. The various quantities of heat are represented in case 2. Although the quantity of heat generated is the same as that in the first case, twice as much of the heat is below the temperature of the boiler water, and, therefore, not available for absorption; the quantity of the heat available is smaller by the same amount. Thus, even should the true boiler efficiency remain constant, a smaller percentage of the total quantity of heat generated will be absorbed because less heat is available for absorption. If the assumed temperature of the gases leaving the boiler be 510 deg. F., the two efficiencies are:

True boiler efficiency,

$$E_4 = \frac{1260 - 510}{1260 - 324} = 80 \text{ per cent.}$$

Efficiency ordinarily used,

$$E = \frac{1260 - 510}{1260 - 60} = 62.5 \text{ per cent.}$$

The above figures show that, although the true boiler efficiency is the same, the ordinarily used efficiency is 8.5 per cent. lower than that in case 1. Finally, so much air could be used for combustion that the temperature of the products would equal that of the boiler water; then no heat would be available for the boiler, and no heat would be absorbed by it. Thus it can be seen that the useful effect of the heat generated diminishes with the drop in its initial temperature. Any factor that reduces the temperature of the products of combustion is the fault of the furnace and not of the boiler. It is therefore wrong to charge, in the above cases, the decreases in the useful effect to the boiler; they are the fault of the furnace and should therefore be charged against the furnace.

True boiler efficiency has the advantage over the ordinarily used boiler efficiency that it takes care of the variation of the temperature of the furnace gases as well as the variation of the temperature of the boiler water, caused by different steam pressures. In other words, true boiler efficiency does not blame the boiler for a lessened steam production caused by a lower temperature of the furnace gases, which really is a fault of the furnace, nor does it blame the boiler for absorbing less heat when the temperature of the boiler water is raised by raising the steam pressure.—*Kreisinger and Ray in Bureau of Mines Bulletin* 18.

Coal Output Doubles in Ten Years

An interesting fact about the United States coal production, according to the United States Geological Survey, is that in each successive decade the output is practically doubled. If the production of bituminous coal alone were considered, the record for the last 50 years would show an increase somewhat in excess of this ratio. It has been estimated that the anthracite output will reach 100,000,000 long tons annually before it begins to decline.

Statistics of coal production show that up to the close of 1865 the total output had amounted to 284,890,055 short tons. From 1876 to 1885, the output was 847,760,219 tons, more than double the total production during the preceding decade. In 1885 the production was 1,552,075,478 tons, and during the 10 years ended in 1895 it was 1,586,098,641 tons. In the decade ended Dec. 31, 1905, the total production was 2,832,402,746 short tons, and the grand total from the beginning of recorded coal mining in the United States was 5,970,576,865 short tons.

The Virginia Power Co. contemplates the erection of three power plants on New River, at Cabin Creek, W. Va., and is preparing plans for the work. It is planned to supply the New River and Kanawha coal fields with power. Complete details of the plants have not yet been worked out. It is estimated that the system will cost about $2,000,000.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

The Synchroscope

By John A. Randolph

The most widely known type of synchroscope is the invention of P. M. Lincoln which was first brought into practical use at the power house of the Niagara Falls Power Co. It successfully met the purposes for which it was designed and was soon generally recognized as almost indispensable in alternating-current switchboard operation. It is used in paralleling synchronous alternating-current machines, its functions being to indicate the speed of the starting machine relative to the running machine, the angle of phase difference and the moment when the machines are in step.

It is far superior to the older method of using incandescent lamps. The latter show the relative difference in speed, but do not indicate whether the starting machine is running too slow or too fast. They also give no indication of the angle of phase difference. Moreover, while a skillful operator can generally determine by the lamps the moment of synchronism with sufficient accuracy for practical purposes, he has no means of ascertaining this instant with precision. The synchroscope, on the other hand, not only shows at all times the relative difference in speed, but it also indicates whether the speed is too high or too low. Furthermore, it gives an indication of the angular difference in phase and shows accurately the center of the beats. By the number and accuracy of its indications, it renders a material service in time saving when starting.

In construction, the instrument is similar to a bipolar, two-phase, synchronous motor with the exception that its field is excited by alternating instead of direct current. Consider a simple coil of wire *A*, Fig. 1. Looking at the bottom of the coil, when current is applied in a clockwise direction a magnetic field will be established with north and south poles, as shown. If the coil is now placed in a field from another source, as in Fig. 2, and is free to revolve about an axis through one of its diameters, it will act similar to a bar magnet under like conditions, the north and south poles being attracted to the opposite poles of the external or main field. The force thus exerted will turn the coil until its field is in the same direction as the main field and will hold the coil in this position as long as the two fluxes remain unchanged. However, upon the reversal of the main field, coil *A*, following the laws of magnetic attraction and repulsion, will take a position 180 deg. from its last position. If the currents in coil *A* and the main field winding are alternating and vary in phase by 90 deg. electrically, no effective turning force will be exerted. Coil *A* may, therefore, be freely revolved and will come to rest in a position independent of the main field. In explanation, consider the sine wave diagram shown in Fig. 3.

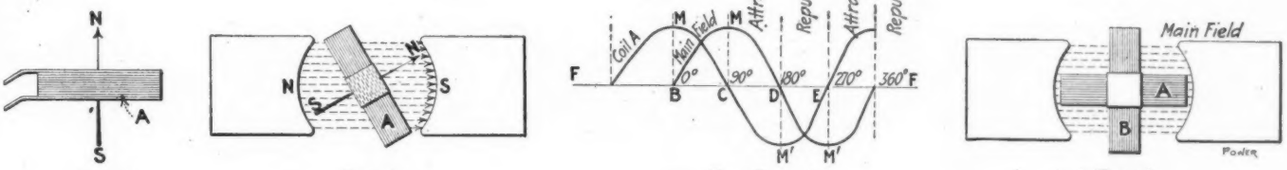


Fig. 1 Fig. 2 Fig. 3 Fig. 4

Illustrating Principles of the Synchroscope

Let the two curves represent respectively the currents in coil *A* and in the main field winding, the frequency being the same for both. Starting from zero value on the line *F-F*, the currents rise in one direction to a maximum at points *M* from which they fall to zero again as the curves cross the line *F-F*. They then rise in the opposite direction to a maximum at the points *M'* whence they again fall to zero, completing the cycle. Consider the 360 electrical degrees representing the cycle divided into quadrants of 90 deg., as shown by the dotted lines at points *B*, *C*, *D* and *E*. It will be seen that when one current is at a maximum the other is at zero and *vice versa*. As a result, no turning force will be exerted at the points *B*, *C*, *D* and *E*. However, between these points a different condition exists. Between points *B* and *C* the currents (and consequently the fields set up by them) are in the same direction, hence the north pole of coil *A* is repelled by the north pole of the field. At the point *C*, however, the current in coil *A* changes its direction, causing a change of polarity in the field set up by the coil. The turning force between points *C* and *D* will therefore be opposite in direction to that between *B* and *C*, and the south pole of coil *A* is attracted by the north pole of the main field. Between the points *D* and *E* repulsion again exists followed by attraction as the curves pass point *E*. It is therefore evident that as the respective currents rise and fall, four impulses will be exerted upon coil *A* in alternate directions, the total or integrated rotating force of which will be zero. If coil *A* had no inertia, it would tend to oscillate through an angle of 90 deg. in response to these impulses. However, in practice, the inertia and friction of the coil must be considered together with the extremely short period of reversal. These elements retard the movements to such an extent that only an indiscernible vibration is produced.

Now let a second coil *B* of the same dimensions and construction as coil *A* be placed on the axis with coil *A* at the same point, but at right angles to coil *A* as in Fig. 4. Let alternating currents be sent through coils *A* and *B* and the main field winding. Consider the current in coil *B* of the same value and relative direction as that in coil *A*, but differing in phase from the latter by 90 deg. Owing to this phase difference, it follows from the previous explanation, that when the force of attraction between the main field and the coil *A* is at a maximum no turning force is exerted upon coil *B* and *vice versa*. When neither of the coils *A* or *B* are in phase with the main field a rotating flux is produced which will cause the movable element to revolve. However, when the current in one of the revolving coils comes into synchronism with that in the main field winding, equilibrium is reached and the coils come to rest.

This principle is utilized in the synchroscope, as shown diagrammatically in Fig. 5. The armature coils *A* and *B* are wound upon a laminated iron core, the angle between them being approximately 90 deg. Upon the armature shaft are three slip rings. The ring *E* is connected to one end of coil *A*, the other end of the coil being connected to coil *B*. From the common connection between the coils

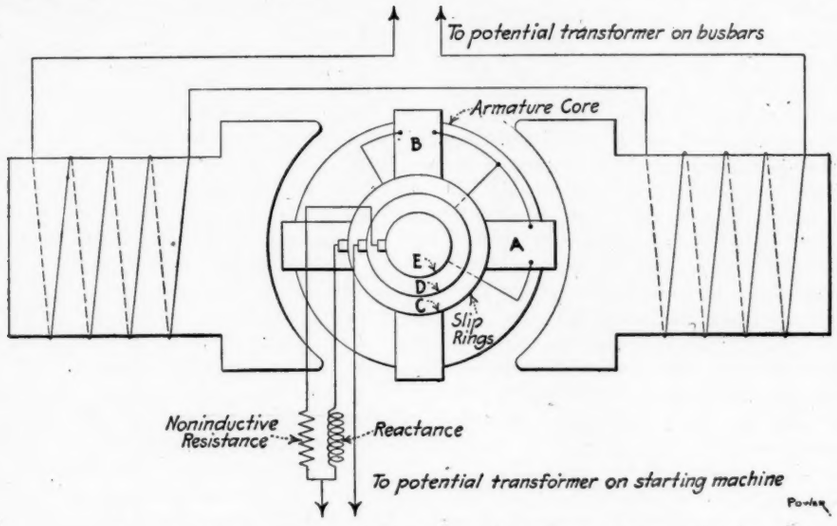


FIG. 5. SHOWING CONNECTIONS OF THE LINCOLN SYNCHROSCOPE

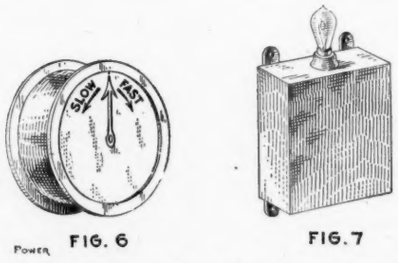
A and *B* a tap is led to the middle ring *D*. The other end of coil *B* is connected to the remaining ring *C*. To secure the required phase difference, the ring *C* is connected through a sliding contact to a reactance coil. The ring *E* is likewise connected to a noninductive resistance. The other ends of the reactance coil and the resistance are connected together and from this connection a lead is carried to the secondary of a potential transformer whose primary is connected across one phase of the starting machine. The other end of the secondary is connected to the middle slip ring *D*. The field coils are wound upon a laminated iron frame, the supply leads being connected to the secondary of another potential transformer connected across one phase of the busbars.

As commercially constructed, the armature and field are inclosed in a case as shown in Fig. 6. One end of the armature shaft extends through the front of the case and carries a pointer which swings over a white dial. At the top of the latter is an index denoting the position which the pointer will take at synchronism. Upon either side of the index are arrows pointing respectively in a clockwise and counter-clockwise direction. The words "fast" and "slow" designate the respective indications relative to the speed of the starting machine when the pointer revolves in the direction of either of the arrows, a clockwise direction meaning that the machine is running at a speed above synchronism and *vice versa*. A complete revolution of the pointer indicates a gain or loss of one cycle by the starting machine as compared with the frequency of the main busbars. The angle which the pointer makes with a vertical line through the index represents the phase difference between the busbars and the starting machine.

The reactance and noninductive resistance are placed in a convenient location outside the synchroscope proper. A common method of constructing these elements is shown in Fig. 7. A coil of wire is used for the reactance and an incandescent lamp for the noninductive resistance. The reactance coil is placed in an inclosing cage and the lamp is fastened to the top of the latter.

THE INDUCTOR TYPE

In this type of synchroscope, all the coils are stationary. The movable element consists simply of an iron armature or core carried upon a shaft; the construction is shown diagrammatically in Fig. 8. Two fixed coils *A* and *B* have their axes in the same plane but at right angles to each other. A third fixed coil *C* is placed centrally to the other coils with its axis perpendicular to the axes of the other coils at their point of intersection. Upon a shaft whose center coincides with the axis of the coil *C* is an iron core located centrally to the coil and carrying at each end a radial projection or polepiece perpendicular to the shaft.



SYNCHROSCOPE DIAL AND REACTANCE BOX

The two polepieces, however, extend in opposite directions from the shaft. When a current is passed through coil *C*, the iron core becomes magnetized and acts as a bar magnet, the polepieces becoming of opposite polarity. If now a current is passed through coil *A* an attractive force will be exerted upon the polepieces which will turn them until the flux emanating therefrom lies in the same direction as that of coil *A*. When the currents passing through coils *A* and *C* are alternating and in phase, the force exerted upon the armature will remain at a maximum holding it in the one position. However, if the two currents differ in phase by 90 deg. no force will be exerted upon the armature; hence it will be independent of the main field and can be brought to rest in any position. (See explanation of Fig. 3.) If an alternating current is passed through coil *B*, differing in phase from that in coil *A* by 90 deg. and coil *A* is out of phase with coil *C*, a revolving field will be produced which will impart a rotary motion to the armature. However, when the current in either coils *A* or *B* comes into step with that in coil *C*, the field will come to rest, bringing the armature in equilibrium simultaneously.

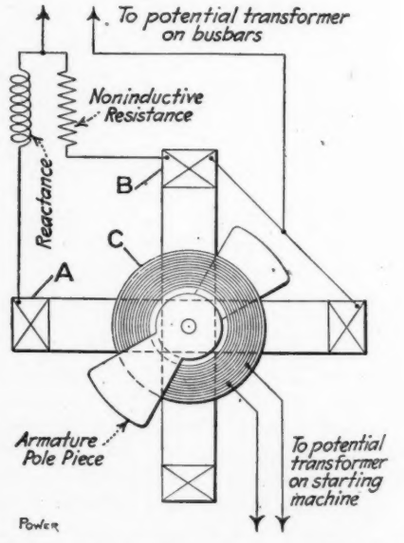


FIG. 8. ILLUSTRATING INDICATOR TYPE OF SYNCHROSCOPE

The phase difference in coils *A* and *B* is produced by a reactance and a noninductive resistance as in the movable coil type. The connections of the coils are as follows; one end of coil *A* is connected to the reactance and an end of coil *B* to the noninductive resistance. The other terminals of the reactance and resistance are joined to a common connection as are also the remaining ends of the coils *A* and *B*. From these common connections, leads are carried to a po-

tential transformer connected across one phase of the busbars. The coil *C*, on the other hand, is fed by a potential transformer across one phase of the starting machine. A pointer carried on one end of the shaft moves over a dial giving indications as in the movable coil type.

General

In practice, the synchroscope is placed upon a swinging bracket in a position such that it can be readily seen from all positions assumed by the operator in starting the various machines. In the larger central stations, an additional synchroscope is placed upon the instrument panel at the machine. The latter instrument acts in unison with that on the switchboard, indicating to the engineer whether the speed is too high or too low.

CORRESPONDENCE

Switch Panel Box

The accompanying illustrations show the details and construction of a panel box for controlling lights, where circumstances make it necessary or desirable to keep all live contacts covered, to prevent persons using them from sustaining shocks and prevent tampering with the fuses, or where sparks caused by the arcing of an improperly closed or opened knife switch might cause a fire.

As shown, the sheet-iron box is divided horizontally into two compartments, the upper containing the snap switches while the lower contains the cutouts and fuses. The cutouts and switches are mounted on wood or slate bases with a barrier of the same material between the switch and the fuse compartments. The cabinets are usually 4 in. deep and 14 in. high, their width depending on the number of switches used. Indicating snap switches are used. The mains are brought in from which ever side is most convenient. In the case shown they are brought in at the right; the branch circuits passing out at the top.

The upper door is secured with an ordinary spring catch while the lower is locked to prevent tampering with the fuses and coming in contact with live parts. The use of snap switches renders their manipulation practically free from shocks. Moreover, their positive opening and closing is entirely independent of the skill of the person operating them and makes them preferable to knife switches in this respect. A person unskilled in the use of a knife switch soon destroys it on account of opening or closing it too slowly and causing an arc. This will burn the blade and clips, sometimes fusing the copper across the clips and preventing the blade from entering. Or, the arcing may cause beads of copper to form on the blade which is closed, resulting in poor contact and heating.

Others again, probably due to ignorance or some previous unpleasant experience with knife switches (in groping for them in the dark when standing on a wet floor) will resort to a stick of wood and use it for closing or opening the switch, sometimes substituting a piece of iron with disastrous results to themselves and to the switch.

P. Justus.

Cleveland, Ohio.

Protecting Reinforced Conductors

In the Oct. 1 issue, C. V. Shear states a method of protecting reinforced circuits by fuses. I cannot agree with his conclusion that it would be better to use but one fuse to protect both wires than to fuse each separately.

The advantage claimed by Mr. Shear for the single fuse is that the two wires are connected together beyond the fuse and therefore the current would divide between them in exact proportion to their conductivity. Although with the second fuse in the circuit there would be a possibility of the resistance of its contacts differing enough from that of the first to make a noticeable difference in the amount of current carried by the second wire, yet this would be only a possibility and would have to be the result of very poor contact, causing a high resistance there, and at the same time a very low resistance in the wires of the circuit. Even if such an unbalancing should occur there would be no chance of its doing any damage by overheating the wire as each wire would be protected by its individual fuse which would blow before the current could reach a dangerous value. Furthermore, if there should be trouble on account of the fuse blowing it would indicate where the trouble might be looked for and, when found, it could be remedied by improving the contact.

As against this remote possibility of annoyance, and nothing more, due to the blowing of the fuse in the unbalanced circuit, there must be considered the actual danger that might be caused by overloading one of the wires when both are protected by a single fuse.

Even when both wires are so large as not to be easily broken there is always the possibility of the insulation on one becoming slightly damaged and permitting the current to leak to some pipe, conduit, or other wire and cause a high resistance short-circuit which would not be heavy enough to blow the one large fuse but which would blow a fuse of half the size.

In one case there is no opportunity for a fire being started by an overheated wire, while in the other there is a chance.

G. H. McKelway.

Brooklyn, N. Y.

Power Dissipating Rheostat

The dissipation of large amounts of energy in electrical testing work by means of rheostats becomes a serious problem on account of the heat generated, and special means of cooling the rheostat must be provided.

For testing a large storage battery at St. Louis, requiring the continuous dissipation of 1,500,000 watts, the device was adopted of using iron pipe as the resistance conductor and of cooling it by circulating water through the pipe. A total length of 369 ft. of 2-in. pipe was used, made up into a grid which was tapped at several points to allow the water to escape without having to pass from end to end of the grid.

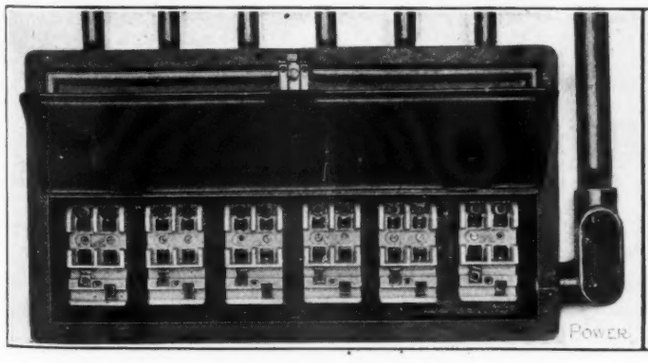


Fig. 1. Panel Box Open

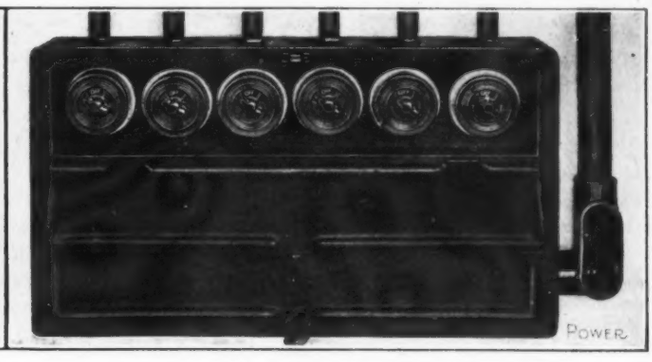


Fig. 2. Panel Box Closed

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Gas Engine with Corliss Releasing Valve Gear

The Hilker-Wiechers Co., of Racine, Wis., after operating its factory for five years with a 50-hp. gas engine and producer, decided to double its capacity in 1910. After careful investigation a 200-hp. Smith combination hard- and soft-coal producer and a 200-hp. complete expansion gas engine were selected; this installation has now been in continuous operation for the past 18 months.

While it was not expected that the present load would be more than 125 hp., the problem of buying an engine which would take care of this load economically, yet have a capacity for 200 or 225 hp. when required, was solved by the installation of a 16x24-in. tandem double-acting engine which would develop one-half, three-quarters or full load with a maximum thermal efficiency by simply cutting out one or more explosion chambers at will. Direct connected to a 150-kw. direct-current generator and with a flywheel sufficiently heavy to produce a satisfactory turning moment with but one, two, three or four explosion chambers working, this engine takes care of any load within its range with a high efficiency. The method of cutting out one or more explosion chambers to suit the load will be apparent under the valve-gear description.

Fig. 1 shows a general view of the engine, from which it will be seen that no piping comes up higher than the bottom of the cylinder and that no moving mechanism extends above the side shaft, leaving the tops of the cylinders plain. The side shaft which is driven by spiral gears running in oil and which may be sued to pump oil through a filter and to all bearings, drives the governor and a single eccentric for each explosion chamber.

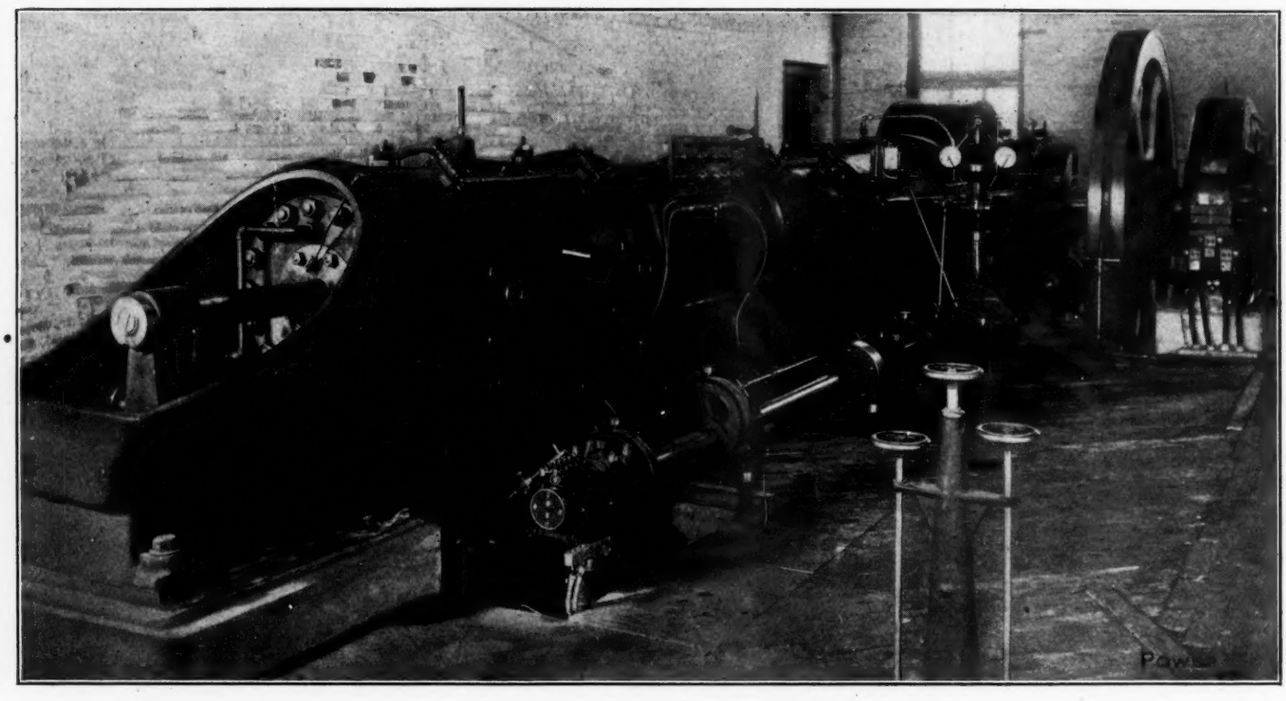


FIG. 1. SARGENT ENGINE IN SERVICE

A cross-section through the explosion chamber and valve mechanism is shown in Fig. 3, and Fig. 2 is a longitudinal section through the valve cage, valve, cylinder and head. When the valves are in the position shown in Fig. 3, the engine is on center and the piston at the end of the exhaust and the beginning of the suction stroke, the exhaust valve having just closed and the admission valve ready to open.

Fig. 4 shows the position of the valve and eccentric after the piston has made two strokes and the crankshaft has turned 360 deg. from that shown in Fig. 3; that is, the beginning of the power stroke.

When the crankshaft has turned 160 deg. during the working stroke, the eccentric has moved clockwise 80 deg. from the position shown in Fig. 4, raising the cam *A*, which is fulcrumed at *B* until the cam *C* through the push rods *E* (Fig. 2) and the exhaust ring *F* raises the poppet valve *G* against the pressure in the cylinder and the air pressure on dashpot plunger *J*. This allows the exhaust to escape through the exhaust ports *H* to the exhaust pipe. A further movement of the eccentric 100 deg. brings the exhaust ring *F* to the position shown in Fig. 3; that is, the end of the exhaust stroke.

When the exhaust is wide open and the cam *A* is in its highest position, the plate *K* engages the hook *L* journaled to the yoke *M* pivoted at *B*, and through rod *N*, levers *O*; arms *P* and collar *Q*, integral with the poppet valve stem, lifts the cut-off valve *R* and poppet *G* against the air pressure on the dashpot plunger *J*, letting in gas at *S* and air at *T*.

As the cam *A* continues to go down during the suction stroke, the inlet and poppet valves rise until the hook *L* engages the knockoff lever *U* (Fig. 4), the position of which is determined by the

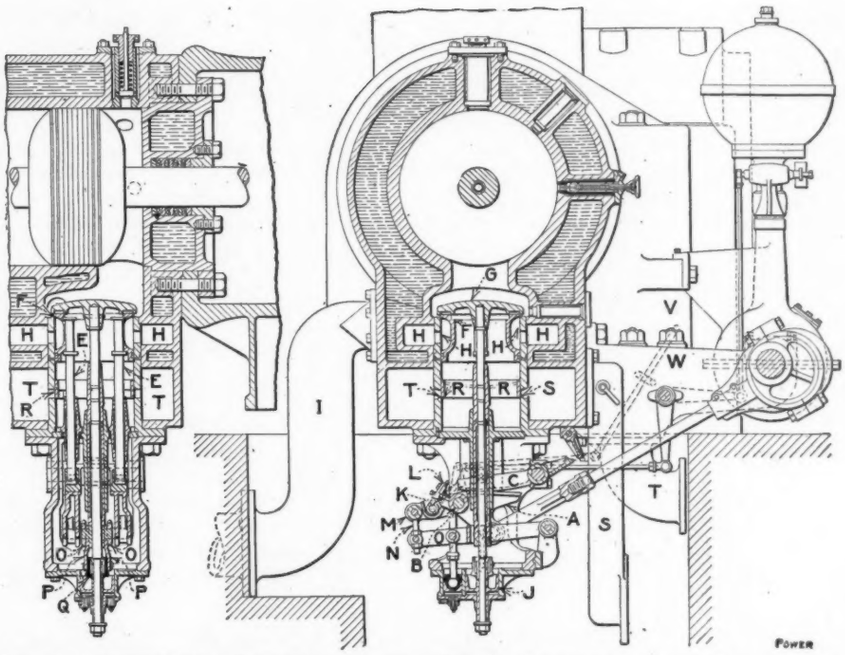


FIG. 2. LONGITUDINAL SECTION THROUGH VALVE MECHANISM

FIG. 3. SHOWING VALVE GEAR, THE EXHAUST VALVE JUST HAVING CLOSED

governor and the load. When the hook *L* is released, air pressure on the dashpot plunger closes both the cutoff valve and the poppet valve quickly and quietly, preventing wire drawing in the cylinder

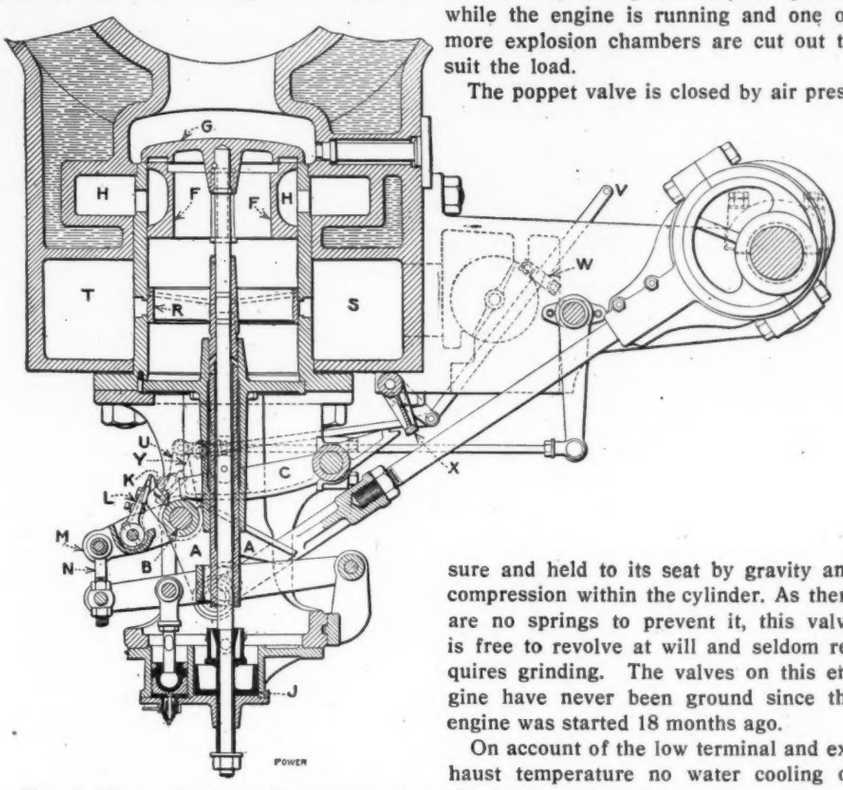


FIG. 4. VALVE GEAR AT BEGINNING OF POWER STROKE

and allowing the valves to return to the normal position shown in Fig. 4.

By raising the handle *V* it unhooks at *W*, allowing the pawl *X* to engage the cam *C*, holding the exhaust valve open and at the same time a secondary knock-off lever *Y* engages the hook *L* and prevents the gas and air valve from opening. In this way an igniter may be put in while the engine is running and one or more explosion chambers are cut out to suit the load.

The poppet valve is closed by air pressure and held to its seat by gravity and compression within the cylinder. As there are no springs to prevent it, this valve is free to revolve at will and seldom requires grinding. The valves on this engine have never been ground since the engine was started 18 months ago.

On account of the low terminal and exhaust temperature no water cooling of the poppet valves is necessary. Valves as large as 45 in. in circumference are used without water cooling with complete satisfaction. By removing six nuts and disconnecting the eccentric and governor rods the valve cage and valves may be removed from the cylinder.

Fig. 5 shows indicator diagrams taken from explosion chamber No. 4 when Nos. 1 and 3 were cut out, also when all the explosion chambers were working.

This engine was guaranteed to develop

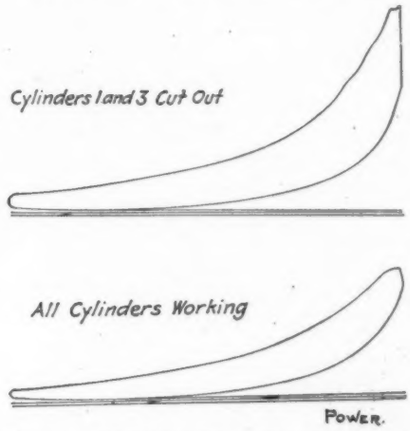


FIG. 5. DIAGRAMS FOR CYLINDER NO. 4 WITH FULL LOAD AND WITH PART LOAD

a brake horsepower on 8750 B.t.u. per hour and was designed by C. E. Sargent, chief engineer of the American Rotary Valve Co., of Chicago, and also Anderson, Ind.

The Chapman Gas Producer

A new design of bituminous gas producer for furnace work has recently been put out by the Chapman Engineering Co., of Mt. Vernon, Ohio, although experimental work on this producer has been in progress for the past six years and several have been in actual service for nearly two years. The new producer possesses several distinctive features, chief among which are the automatic feed, the manner of agitating the fuel bed and the method of removing the ashes.

Referring to the sectional view, Fig. 2, it will be seen that the top and bottom are stationary and the shell movable. The latter is divided through the hot zone into an upper and a lower section, the sections revolving, by means of the shaft and gears at the left, in the same direction but at different speeds.

Each section of the wall carries with it that portion of the fuel bed which it surrounds. Thus, without employing any agitating arms, agitation is produced through the hot zone where it is most required.

The fuel chamber has a capacity of 1000 lb. of coal—enough for half an hour. It is stationary, has no bottom and the lower edge is water-cooled. As the revolving bed of fire comes under this chamber a fresh supply of fuel is spread over the surface, thus constantly maintaining the level of the fire bed up to the bottom of the fuel chamber. It is claimed that this arrangement effectively handles fine and coarse coal simultaneously with-

out separating the latter from the former as is so often the case where a spout is employed.

The lower edge of the fuel chamber is beveled so as to produce a down-stroking effect upon the fire bed as it passes under, thus "rubbing in" the fresh fuel. Furthermore, the makers claim that the rotation of the fire bed tends to prevent the formation of blow-holes and clinkers.

The ashes are first ground between the sides of the stationary corrugated air box and the revolving corrugated wall of the lower section. After the ashes are crushed they are forced up to the top of the ash pan by three adjustable ash plows. These are kept continually in operation. As fast as the ashes are lifted to the surface of the water in the ash pan, they are automatically scooped up and carried to the discharge point. The fact that the ashes are removed upward instead of downward makes it possible to save several feet in the height required for the gas house and foundation.

Referring to details, the supporting rollers run on high carbon-steel pins, and are provided with brass bushings. Separate rollers take the side thrust and all the rollers are mounted in pairs set in equalizing yokes. The bearings are provided with large oil wells filled with waste after the manner of railroad cars. The faster gears run in oil.

The station cost per kilowatt-hour at the switchboard of only ⅝c. at the new plant of Bamberger & Co.'s department store, Newark, N. J., speaks well for the equipment and management.

CORRESPONDENCE

Heat Value of Liquid Fuels

An article in the Sept. 17 issue entitled "The Heat Value of Liquid Fuels," by A. A. Potter, gives results of a number of determinations of thermal values. The writer has had occasion to make a number of similar determinations on 60 deg. Bé. gravity gasoline and on fuel oils, using a Mahler bomb calorimeter. The samples of liquid fuel were placed in gelatine capsules for convenience in handling; otherwise the procedure was the same as when testing solid fuels. The heat value of the capsules and the calorimeter constant were accurately determined beforehand and due allowance was made therefor. Great care has to be taken to prevent leakage or evaporation of the liquid fuel after it has been weighed. The heat from the fine steel wire used in the ignition must also be considered.

By the Mahler bomb method the writer found that 60 deg. gravity gasoline averaged 20,100 B.t.u. per lb. instead of 19,411 B.t.u. as determined by Mr. Potter. This applies to the Eastern gasolines. A few samples of gasoline from California crude oil averaged about 19,800 B.t.u. per lb. In gravity and appearance the California gasoline was identical with the Eastern product but had a different odor. On a comparative test of 100-gal. lots in a gasoline motor car there was a marked difference in favor of the latter. When all weights and calorimetric readings are taken with great care and precision, very little variation is found in the resulting thermal values.

Samples of California crude oil of 18 to 24 deg. gravity which have been freed from moisture show a thermal value averaging approximately 18,700 B.t.u. per lb. A variation of nearly 1000 B.t.u. per lb. is found in samples of crude oils from different fields. On a comparative test of Wyoming coal and liquid fuel made a few years ago, the writer obtained an evaporation of 3780 lb. of water per barrel of 18 deg. gravity oil (336 lb. per bbl.) against an evaporation of 12,460 lb. of water per ton of run-of-mine coal. The thermal value of the coal averaged slightly over 12,000 B.t.u. per lb., which makes 3.3 bbl. of oil equivalent to one ton of coal; ordinarily 4 bbl. are taken as the equivalent of one ton. In burning liquid fuels much less draft is required than with solid fuels; otherwise the efficiency will be seriously impaired by an excess of air. It was found that a draft in the stack not exceeding 0.15 in. of water gave best results on a boiler of 100 hp. capacity using liquid fuel. A slight variation in the pressure of the atomizing medium will often produce a radical difference in the efficiency of combustion.

Reno, Nev. J. C. SCRUGHAM.

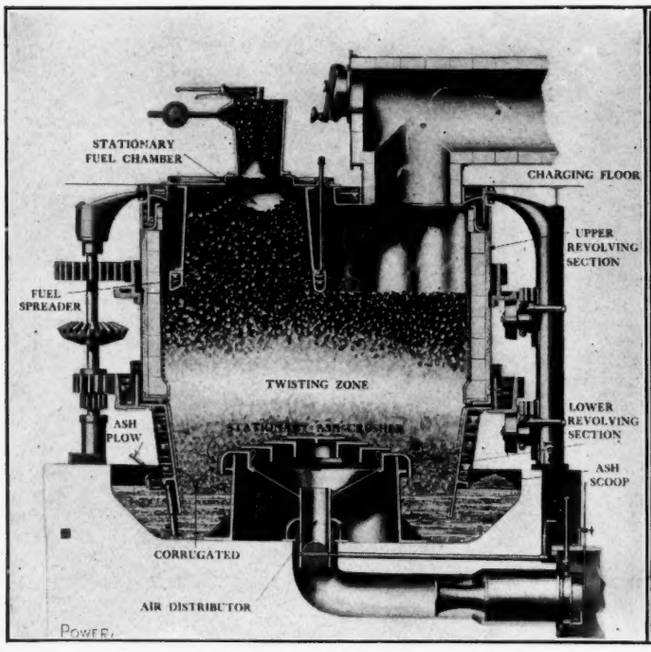


FIG. 1. SECTION THROUGH CHAPMAN PRODUCER

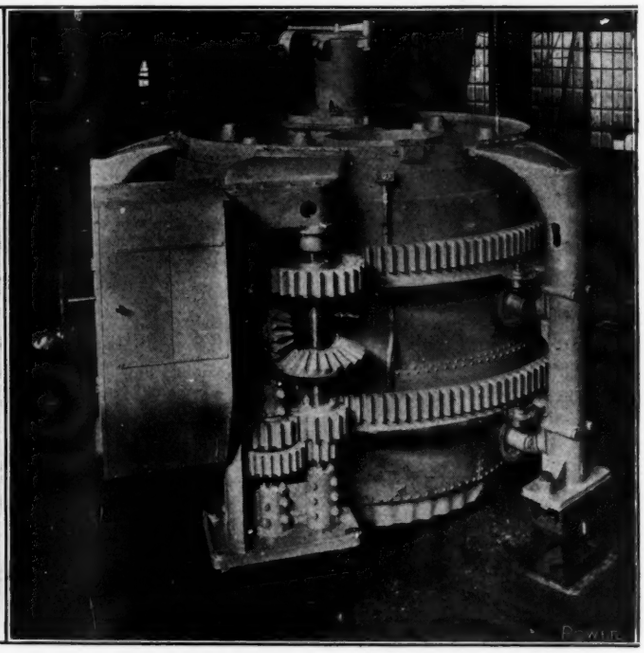


FIG. 2. EXTERIOR OF CHAPMAN PRODUCER

Attention has been called to the fact that in traction power houses, where for about three hours in the morning and in the evening it is necessary to develop twice as much power as during the rest of the day, plants which are equipped to burn oil have no difficulty in developing double the normal rate of temperature for each boiler regardless of draft conditions.—*Electric Railway Journal.*

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Refrigeration by Direct Expansion and Brine Circulation

By John Creen

Among the different ways in which refrigeration is communicated by pipe coils, the direct-expansion system is more generally employed, being the most economical to construct as well as to operate. The ammonia or other refrigerating medium in the coils expands directly in the rooms to be cooled. When the amount of refrigeration required for a room in a given time is known, the amount of surface or the size and length of expansion coils required may be calculated on the basis, that about 10 B.t.u. will pass through every square foot of coil surface, per hour, for every degree difference between the temperature of the room and that of the ammonia within the expansion coils.

If R is the amount of refrigeration in tons required for a room in 24 hr. and t and t_1 the temperatures in the room and within the ammonia coils respectively, the number of square feet of pipe surface will be

$$S = \frac{R \times 284{,}000}{24 \times 10\,(t - t_1)}$$

The result in square feet may be readily converted into linear feet of pipe. Each 1.6 linear foot of 2-in. pipe has 1 sq.ft. of surface and for other sizes, tables of pipe dimensions may be consulted.

In practice, conditions are variable, owing to the difference in amount of pipe surface at different times, brought about by atmospheric conditions, by deposits from the water, as in the condenser, by the difference in the insulation of the rooms to be chilled, etc. For these and other reasons the above formula is subject to modification to meet special and individual cases.

The size of pipe usually employed for piping rooms varies from 1 to 2 in., and the length required varies according to circumstances, more especially with the temperature or the pressure of the expanding ammonia and the temperature at which the rooms are to be held. If a room is to be kept at 34 deg. and the temperature of the expanding ammonia is 10 deg., it will take only half as much pipe to convey a certain amount of refrigeration as if the temperature of the expanding ammonia were 22 deg. In the latter case, however, the machine works under far more economical conditions and using the larger amount of pipe so as to work with a higher back pressure is advisable.

In allowing a difference of 8 to 15 deg. between the temperatures inside and outside of the pipes it is variously assumed that in direct expansion 1 sq.ft. of pipe surface will convey 2000 to 4000 B.t.u. in 24 hr. This nearly agrees with the transmission of heat at the rate of 10 B.t.u. per hr. per sq.ft. of surface for each degree Fahrenheit difference between temperatures inside and outside of the pipe. With brine circulation, the brine with the same back pressure in the ammonia coils has a much higher temperature than the ammonia so that from 1½ to two times as much pipe is used.

If the piping is calculated on the above basis, the result will generally fall short of the piping required after the practical "rules of thumb" given in the next paragraph. These rules are founded on a very liberal basis calculated to cover unfavorable cases, as regards insulation, size of rooms, etc., it being understood that any possible surplus in piping will tend to increase the efficiency of the machine.

About one running foot of 2-in. pipe (direct expansion) will take care of 10 cu.ft. of space in rooms which are to be kept below freezing down to a temperature of 10 deg. F. On the same basis one running foot of 2-in. pipe will take care of 40 cu.ft. of space in rooms to be kept at or above the freezing point, 32 deg. F. or thereabouts. About one running foot of 2-in. pipe will take care of 60 cu.ft. of space in rooms to be kept at 50 deg. F. and above.

These rules are intended to cover rooms of 50,000 cu.ft. capacity and less, poorly insulated and operated with small differences in temperature. On a still more liberal basis it is frequently assumed that one ton refrigerating capacity will take care of 4500 cu.ft. of cold-storage capacity to be held at 32 to 35 deg. F. and that from 260 to 300 ft. of 1¼-in. pipe should be used to distribute one ton of refrigeration expediently and satisfactorily. One running foot of 2-in. pipe is equal to 1.44 ft. of 1¼-in. pipe and 1.8 ft. of 1-in. pipe as regards surface.

Brine Circulation

Formerly it was considered risky to use the direct-expansion system in storage rooms as possible leakage might cause great damage. On this account the brine system was very generally used. In this system the expansion coils are in a separate vessel or tank containing salt brine, which is cooled to the desired temperature. The brine is then pumped through pipes in the rooms to be refrigerated. In ice making the cells or cans containing the water to be frozen are suspended in the brine tank.

For general refrigeration from 120 to 150 running feet of 1¼-in. pipe in the brine tank is allowed per ton of refrigerating capacity in 24 hr., and for ice making 250 to 300 running feet of 1¼-in. pipe.

As the brine does not circulate as fast as the ammonia vapor, the surface of the brine coils in the storage rooms must be greater. In round figures it is generally assumed that the area of pipe surface should be from 1½ to two times as great as is required in direct expansion. The size of the brine pump should be estimated on the basis, that the brine should not travel faster than 60 ft. per min.

Sodium chloride or common salt has been commonly used for brine, but of late years calcium chloride is also largely used. It is convenient in preparing the brine to use a water-tight box, 4x8 ft., with a perforated false bottom and compartment at the end, with an overflow pipe for the brine to pass off through a strainer. In making sodium-chloride brine, the salt is spread on the bottom and the water fed in below as fast as a solution of the proper strength will form.

For refrigerating purposes brine should contain from 1 to 2 lb. of salt per gallon, or in general, sufficient salt to prevent its freezing at the lowest temperature in the freezing tank. If the temperature in the freezing tank does not go below 15 deg. F., 15 per cent. of salt is enough; if the temperature of freezing does not go below 20 deg. F. a brine containing only 10 per cent. of salt would be sufficient. Using stronger solutions of salt than these is unnecessary, for the specific heat gets smaller as the concentration of the brine increases and consequently the stronger the brine, the less heat a given amount of brine can convey between certain definite temperatures.

The clogging of pipes by depositing salt is another reason against the use of too strong brine. This danger, however, is not so great as that of having the solution too thin, for while it may be concentrated enough not to freeze in

the brine tank, it may be too weak to withstand the temperature existing in the expansion coil, so that a layer of ice will form around the latter and interfere with the prompt absorption of heat from the brine. For this reason the surface of the expansion coils in the brine tank should be inspected from time to time to see if any ice has formed.

Many prefer to use calcium chloride for the brine. It costs more, but keeps the pipes cleaner, causing less wear and a better conduction of heat. The freezing point can be depressed several degrees lower; hence it must be used in extreme cases. Adding a small quantity of soda to common salt brine will make it as noncorrosive as calcium chloride.

An advantage frequently cited for brine circulation is that comparatively large quantities of refrigerated brine are made and stored ahead, a supply which can be drawn on if the machinery should have to be stopped. In case of a prolonged stoppage in a small plant refrigerating brine made by dissolving ice and salt together can be circulated through the brine pipes. This, of course, is impracticable with direct expansion. It is further claimed that in small plants the general machinery may be stopped at night and only the brine pump kept going to distribute the surplus refrigeration which has been accumulated in the brine during the day's run.

Refrigerating Plant in Government Printing Office

By W. R. Metz

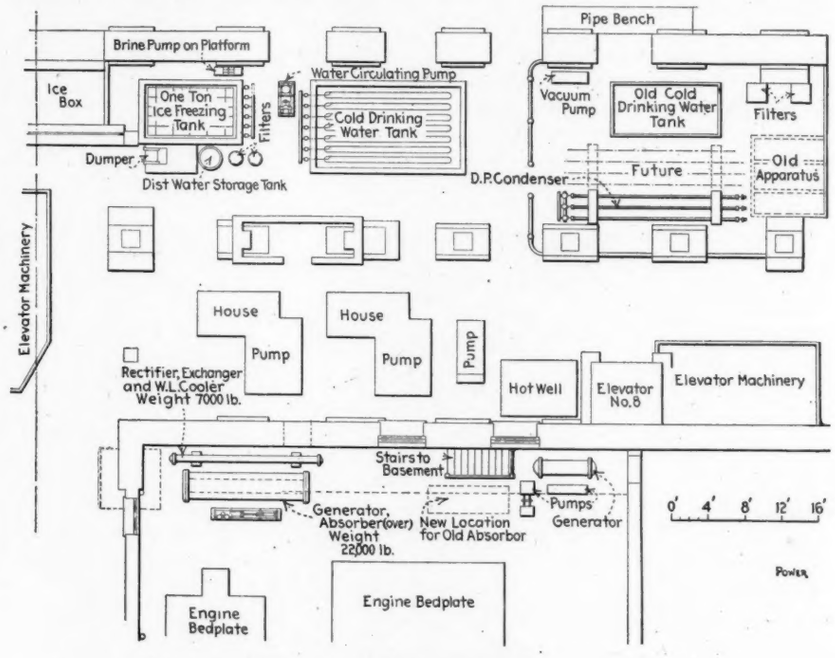
The Government Printing Office has a floor area of about 13½ acres divided up into the new building, eight stories high which is the plant proper, the old building four to five stories high used for storage and sorting purposes, and the annex seven stories high used by the superintendent of documents. All of the buildings are equipped with drinking-water fountains, and cold drinking water is constantly circulated.

When the new building was erected a drinking-water plant was installed, its capacity being 4000 gal. in 24 hr., based on entrance water at 70 deg. F. cooled to about 40 deg. F. This plant was very efficient, but during the past two years the daily consumption of water was so great that a larger plant had to be installed.

The Government Printing Office employs approximately 4000 people, and during the severe hot spell in July and August, the daily consumption rose to 6000 gal. per 24 hr. This was partly due to the fact that the entrance water often reached 85 deg. F., so that it was impossible to cool the water to less than about 50 or 60 deg. F. It is interesting to notice that when the water was cooled to about 50 deg. F., 6000 gal. were consumed, but when it was cooled to 38 deg. F., the consumption dropped to about 4500 gal.

Specifications for the new plant were issued under date of Feb. 9, 1912, calling for a plant of 20-ton refrigerating capacity per 24 hr. in the cooling tank, with 115 lb. pressure at the throttle valve and inlet water calculated from a temperature of 86 deg. In addition the plant must be able to produce one ton of clear merchantable ice every 24 hr.

An absorption system was eventually selected. The absorber is of the horizontal type, the cooling surface consists of 2-in. No. 12 gage charcoal-iron tubes expanded into the heads. The ends are baffled for passing water 12 times through the absorber, which is 28½ in. in diameter by 14 ft. long, with 498 sq.ft. of surface.



Layout of Plant for Government Printing Office

The exchanger is of the multi-tube type, consisting of outer 8-in. pipe welded to forged-steel heads, into which are expanded seven 2-in. No. 11 gage charcoal-iron tubes, the surface area being 117 sq.ft. The weak liquor cooler has 117 sq.ft. of surface and the rectifier 58 sq.ft. The condenser consists of three stands of double pipe 2½ and 1½ in. in diameter and 20 ft. long with the necessary valves and headers for flushing connections.

The generator is horizontal and has an evaporating surface consisting of 1½-in. redrawn extra-heavy pipe with steel return bends, connections to headers being made outside of the generator. The generator cylinder is made of charcoal iron to resist the action of boiling ammonia.

For circulating the water a 7½ and 5 by 6-in. duplex brass-lined pump is provided, while the ammonia pump is 10 and 4 by 10 in. The cold-water steel storage tank, having a capacity of 6000 gal., is insulated with cork on the bottom and sides, and sheathed with 1-in. tongue-and-groove pine boards. The top of the tank is covered with two sections of tongue-and-groove flooring lined between with waterproof paper. This tank is fitted with 4500 lin.ft. of 1¼-in. galvanized-iron pipe, extra heavy.

For ice making a freezing tank made of ¼-in. steel and accommodating twenty 200-lb. ice cans, 10x20x36-in., is provided. The cans are made of No. 16 galvanized steel. The expansion coils are made of 1¼-in. extra-heavy, wrought-iron pipe. The plant is equipped with the necessary distilling and filtering apparatus, thawing apparatus, automatic can filler and geared truck hand hoist. For its operation three men are employed, one on each of the 8-hr. shifts, and one additional man for about 2 hr. each morning to pull the ice.

A Large Steam Turbine

One of the largest steam turbines built in one casing was recently delivered to the Rheinisch-Westfälischen power station at Essen, Germany, by its makers, Escher, Wyss & Co., of Zurich.

This turbine is designed to develop 22,500 hp. under normal continuous working at 1000 r.p.m. The initial steam pressure is 150 lb. per sq.in. above atmosphere and the steam temperature 572 deg. F. at the throttle, exhausting to a vacuum of 27½ in. It is claimed that this turbine can develop 28,000 hp. under constant working and up to 30,000 hp. for short periods.

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POWER

Scale in Turbines

On another page of this issue an article on the removal of scale from turbine blading indicates that it is possible for scale-forming matter to be carried over with the steam. With the proper degree of superheat and the supply line equipped with a separator and strainer this condition is surprising. It is not difficult to see how it could happen in a turbine using saturated steam or steam slightly superheated, and more especially when the character of the feed water is such as to cause frequent priming. We have heard of a case where cold water was turned into the line at a point just preceding the turbine nozzle to reduce the superheat, and with such practice it would be surprising if serious scaling did not occur. It is quite common for oil to work its way into the turbine and with the rust on the metal form in the course of time a gummy deposit which may be scraped off with a knife or cut from the blading by injecting kerosene into the intake as suggested by the article referred to.

It is difficult to account for this hard scale which must be chipped off with a chisel and comes over in sufficient quantity to eventually choke up the buckets. Ordinarily it should be precipitated in the boiler, but scale is common in the superheating tubes, and if scale-forming matter can be carried in suspension thus far, why not to the turbine?

That the separator will not always remove suspended matter, particularly with the tremendous velocities now common in steam mains, is made evident by a case in point. In a number of blowing engines, which had been giving good service, a serious cutting of the cylinders suddenly developed. The trouble was first laid to the oil but its source was soon proved elsewhere by a test of the quality and cleanliness of the lubricant. Eventually it was remembered that the trouble had started shortly after using a mechanical cleaner in the boilers. The fine particles of scale had not been removed by a thorough washing of the boilers, and had come in considerable quantity past the separators and into the cylinders of the engines. If this were possible in an engine it might readily happen in a turbine as the velocity of steam supply is usually fifty to one hundred per cent. greater.

We would be glad to have the experience and opinions of our readers on this question of scale. There are in service in this country a large number of turbines operating under different conditions of steam supply and superheat and furnished with steam from feed water of varied composition. Experience should not be lacking and what we want are the results with the specific conditions under which they were obtained. Let us have your information on the subject for the benefit of all concerned.

To Contributors

Not infrequently, after a contribution received by POWER has been edited, set up, illustrated, paid for and is about to be published, the same material, by the same author, appears word for word in another paper. Sometimes, also, after we have published a purchased article, one of our contemporaries produces the same article, doubtless because it likewise was imposed upon.

One would naturally suppose that an author, having sold a manuscript to one publisher, would understand that the subject matter of that manuscript, or at least the presentation of it therein contained, became the property of the publisher who had accepted and paid for it, and that the author had no more right to sell it over again than he would have to sell his horse or any other piece of property to a number of separate purchasers. It would seem as though a man whose ideas were so good that a publisher would want to buy them would have sense enough to know that after he had sold a thing it did not belong to him to sell again. Yet over and over, we find contributors practicing this duplicity, and, when called to account for it, in-

genuously explaining that they knew no better.

The publication of a duplicated manuscript of this kind puts the publisher of the later presentation in a very awkward position. Those who have already seen it naturally conclude he copied it without crediting its source; a rare but still occasional breach of journalistic ethics. Even if the duplication is discovered before the second publication, the publisher has lost a considerable amount expended in editing, composition, making of engravings, etc.

Another trick of some contributors which leaves the publisher not quite so defenseless but often catches him napping, is to rehash matter taken from one paper and submit it as original material to another.

We are glad to pay for new knowledge, new ideas, or for a more clever presentation of old facts or known methods, but we will not knowingly consider matter which has been sold to other publications. If it is accepted, paid for and used by POWER, we want it understood that POWER is the sole licensee to its use.

The Situation in Flanged Fittings

In our issue of Aug. 13 a comparison was made of the two standards for flanged fittings and editorially we suggested a joint committee to settle all differences. Up to the present, however, no progress has been made in this direction.

To determine the extent to which these standards had been adopted by manufacturers of fittings, valves and steam specialties, about seventy firms were circularized with the request that they indicate their position on the standards. Of the replies received thirty-seven gave information pertinent to the question.

One firm stated that it would furnish either standard as ordered and at the same price; five were undecided; seven advised that the "U. S. 1912 Standard" had been adopted, and twenty-four reported that they would follow the "Manufacturers' Standard." In the majority group are included the largest makers of fittings in the country, but in every case the replies from these firms made it plain that the "U. S. 1912 Standard" would be furnished, though at a special price.

We sincerely regret this setting up of rival standards, when the purpose of the movement which brought them into being was to develop a single standard for the benefit of user and manufacturer alike. The confusion, instead of having been lessened, is now greatly increased, and may become intolerable unless one or the other standard gives way or a compromise is effected.

Probably the manufacturers intend the additional charge for "U. S. 1912 Standard" fittings as a handicap which will automatically turn the tide in their favor, but the other standard is of too great importance to be shelved in this manner. The engineering merits of the two standards should be the real issue, and in this connection greater safety and eventually greater convenience to the user are on the side of the "U. S. 1912 Standard."

After all the user should have a good knowledge of what is wanted. The fittings installed in his plant are under daily inspection and in the course of time the defects become evident. The committees of the engineering societies who are responsible for their schedule included some of the most prominent engineers in the country and some of them the largest users of fittings. These men, drawing upon their extended experience and all the data that it was possible to get, formulated a schedule with safety and convenience as the chief objectives. They had the consumer in mind, for it is really he who foots the bills and uses the equipment. Logically they should receive his support, and if they do the "U. S. 1912 Standard" will be generally adopted.

If this standard is specified by users of flanged fittings and flanged steam specialties the manufacturers will be compelled to change their attitude. The law of supply and demand is as decisive here as for any other commodity.

There is no denying that the manufacturers should have some voice in the formation of the schedule, but they had their opportunity and persisted in viewing the question from a monetary rather than an engineering standpoint. The schedules are not so far apart that a compromise could not be effected, but as this solution now appears to be altogether unlikely we would strongly urge the user to adopt and specify the "U. S. 1912 Standard."

It is his duty to stand behind the engineering committees which have worked in his behalf. In ordering new equipment he should specify their standard and reduce the present confusion to one schedule which appears good enough to last as long as present materials and pressures are employed.

Germany and the Standard Oil Co.

According to the latest press advices the German Government is now taking an active hand in a movement to prevent monopolistic control of its oil supply by the Standard Oil Co. The proposed method of attacking this problem appears to lie in stimulated competition to be brought about by the creation of a government monopoly. By this it is not meant that the German Government proposes to enter actually into the oil business; but rather it is to grant a license to a group of private individuals to form a monopoly under strict government supervision, including the regulation of prices, etc. It is understood that this license will carry with it the right to buy out independent companies by condemnation proceedings, if necessary.

To Germany an adequate oil supply at nominal prices is of vital economic importance as a very large part of the power generated in that country is produced from this source. Profiting, no doubt, by the experiences of this country in attempting to handle the same problem, Germany appears determined to take action while it is yet time and before the monopoly has become too firmly rooted. In this she seems to realize that the only way of fighting monopoly is for the government to assume the right to keep the price of a commodity, necessary to the welfare of its people, at a price which will pay a fair profit upon the cost of production rather than to let private operators fix it at "whatever the traffic will bear."

It may interest those authorities who contend that coal deteriorates rapidly when stored under water to know that coal which has been under water for fourteen years in Havana Harbor has been analyzed by the Bureau of Mines and found to have a heat value of 15,458 B.t.u. It was sunk with the old battleship "Maine."

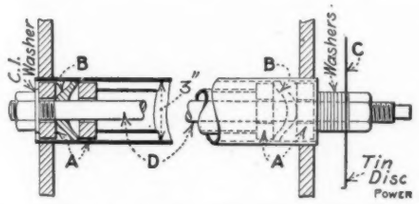
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Metallic Tube Stopper

An effective tube stopper and one that I have frequently used with success is shown herewith. When a tube bursts the hole is not often more than ⅜ in. in diameter. Occasionally though when a tube collapses the stopper cannot be inserted and then I have found the cast-iron washers and jointing to be the quickest method of repair. With the stopper I have often stopped a leak without taking the boiler off the line.

It is quite common to put in stoppers



DETAILS OF METALLIC TUBE STOPPER

while the boiler is under 180 lb. pressure. The washers *A* on each side of the white-metal disks *B* are just rough castings. The bore can be ⅛ in. larger than the diameter of the rod *D*. A tin disk *C* is put on the front end which saves one from getting scalded, as the water rushes out 3 or 4 ft. from the tube if it is a bad burst.

When the stopper is in place a tap wrench is put on the square end and the nut is screwed up with a spanner. This spreads out the white-metal disks into a flat washer and they bind on the rod and around the tube. These washers will keep tight for months and can easily be drawn out by slackening back the nut when there is time to put a new tube in. It is a great advantage to be able to make this repair quickly.

J. A. CAMPBELL.

Providence, R. I.

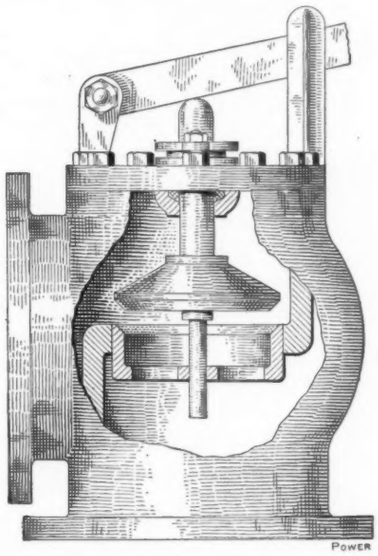
An Unsafe Safety Valve

An instance illustrating the importance of the care of safety valves came to my observation recently. Some oil got into the boilers, and to offset its evil effect, the engineer used soda very freely. This was doubtless part cause at least, for a condition brought about in the safety valves, which was indeed dangerous.

One boiler was made ready for the inspector and after having passed internal inspection was filled for a hydrostatic test. For some reason a delay of about a week occurred during which time the boiler remained full of cold water to the point of overflowing at the safety valve. After the test was made, and the boiler passed by the inspector, it was warmed up, and put into service. Some hours after this the engineer noticed a gage pressure of 115 lb. with the safety valve not blowing. As 100 lb. was allowable the pressure was at once reduced to the point where the valve should have opened.

Once operating, it continued to blow until a reduction of pressure to 70 lb. was reached.

Upon the first opportunity the boiler was again taken off the line and the valve examined, which showed that a gummy deposit had accumulated at and around the valve stem and seat. The stem was so coated as to make it almost impossible for it to slide in the guide which was about 3 in. long. This was evidently the cause for the valves sticking shut. Also the valve and seat were covered to the depth of about ⅛ in. with



SHOWING PARTS OF SAFETY VALVE

the same deposit. This was doubtless why the valve failed to seat and close tightly.

Having told the inspector about the occurrence and that no trouble had been experienced before, he explained it thus: Steam will carry and deposit certain particles of matter which are the product of boiled soda and oil. This deposit had accumulated about the safety valves, but had not affected them as long as the boilers were hot, but had hardened when allowed to become cold.

EDWARD T. BINNS.

Philadelphia, Penn.

Considerations Before Reboring a Cylinder

Recently I was called upon to decide, whether an engine with a worn cylinder would stand reboring, or whether it would be advisable to order a new cylinder. As master mechanics and chief engineers have frequently to make the same decisions, the explanation of the way I proceeded will perhaps prove of interest. The original diameter of the cylinder was 36 in., but it was bored eight years ago to 36¼ in.

Indicator cards taken recently showed that quite a loss was being sustained through leakage of steam past the piston, and an examination of the cylinder showed that it was worn out of round, so that the engine was not working economically. To true up the cylinder would require boring it out ¼ in. larger, or to 37½ in. in diameter. The steam pressure was 150 lb., and the first question that came to my mind was that after another reboring, would the cylinder walls be strong enough to stand the pressure. With an air drill, I bored the cylinder in three places, using a ¼-in. drill first on the bottom, and then on each side, being sure that I did not strike any ribs.

I found that the thinnest place after truing up the cylinder would be ¾ in. I then started to figure, by using the following formula:

$$T = \frac{PD}{2S} = \frac{150 \times 37\frac{1}{2}}{2 \times 2000} = 1.4 \text{ in.}$$

in which

D = Diameter of cylinder in inches;
P = Pressure in pounds per sq.in.;
S = 2000 lb.; safe working strength of cast iron;
T = Thickness of walls of cylinder in inches.

A safety factor of 10 and 20,000 lb. as the ultimate tensile strength of cast iron were used.

Substituting in the formula I found that with a pressure of 150 lb. it would require a wall thickness of 1.4 in., while after the cylinder was bored out I would have only a ⅞-in. wall, which was good for about 93 lb. pressure. As the bore would also come close to the cylinder-head studs, and the valve chambers needed reboring, also as the cylinder was

slightly cracked in the ports, I decided that the old cylinder could not be rebored and be safe, so a new cylinder was ordered immediately.

A. RAUCH.

Pittsburgh, Penn.

Piping Details and Drafting Problem

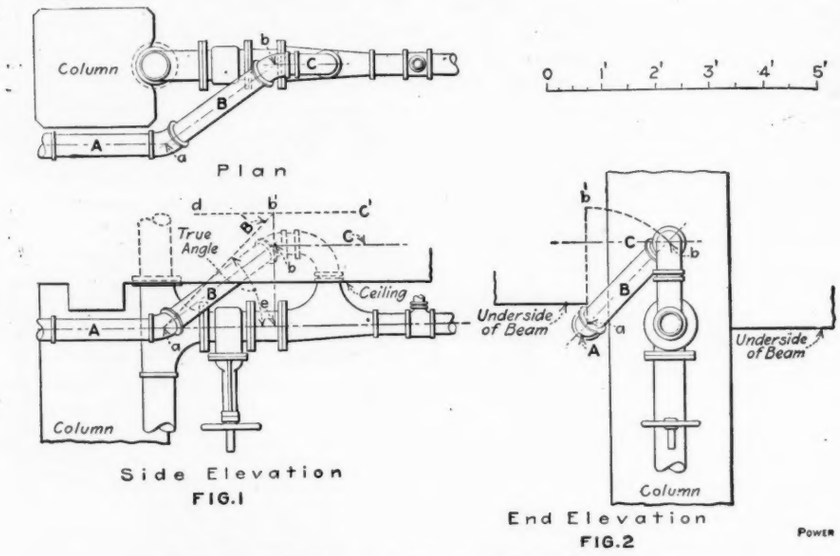
My attention was called to this short-cut method described below, when I expressed surprise at the time lost by some draftsmen in laying out power-plant piping.

Given three views of two parallel pipes, *A* and *C*, connected by a third pipe, *B*. To determine the true angle of the fittings connecting *A* and *B* and *B* and *C*. When the pipes *A* and C are in the same plane as their projection, the projected angle will be the true angle. Therefore (see Fig. 2), when line *ab* is revolved to the new position *ab'*, the point *b* will be on the line *C*, where *b'* meets the line *C* when *ab'* is revolved.

These problems may seem very elemental as they are, but they take less time than the lengthier process as described in some books on descriptive geometry.

H. W. TERRY.

Chicago, Ill.



SHOWING MANNER OF LAYING OUT PIPING DETAIL

side elevation will give the true angles. The line *ab* in revolving about the point *a* will generate a cone. Therefore, in Fig. 1, *a* will remain fixed and *b* will always be on a perpendicular through its original position. Therefore, *b'* is the new position of *b* and the angle *eab'* is the true angle of the fittings.

To calculate this angle we either know or can determine the length of *B* in Fig. 2. We also know or can determine the length of *ae*, Fig. 1.

Tangent of the angle $eab' = \frac{b'e}{ae} = \frac{B}{ae}$.

Angle $db'a = eab'$

because *A* and *C* are parallel.

We also can start with the assumption that *A* and *B* are connected by a 45-deg. fitting and that *ABC* is the elevation. Fig. 1, with $eab' = 45$ deg., *AB'C'* is the true projection or is the side elevation of the revolved position of *ab*. In Fig. 2, the

Silica in Feed Water

Frequently it is stated that water with less than ten grains of hard matter to the gallon is considered good for steam-generating purposes, but this is very misleading in some cases.

It depends altogether upon what the nature of the hard matter is. I have used water with only 4½ grains to the gallon that proved very bad for boilers, especially in forming scale, but it contained 1.65 grains of silica to the gallon, which is one of the worst minerals we have to contend with. It does not make a very thick scale, but it is so hard that it does not have to get very thick to be exceedingly dangerous, especially when it gathers around the end of the tubes at the back of the boiler. Scale will form the heaviest near the tube ends where they go through the head and it does not take long for it to bake hard enough to allow the tube end to be badly burned. This will cause more leaky tubes than anything else, for as soon as the tubes burn, the scale falls off and the water strikes the tube and shrinks it; then it starts leaking.

When I took charge of the plant this water was used. The manager said that he had not been able to get an engineer to stay more than a month, and this was evidently true from the list of names covering a period of two years. If an engineer did not quit he was discharged and if he was not discharged he quit anyhow. When the boilers began leaking in the daytime the night man blamed the day man for letting the water get low and burning the boilers, and when they began leaking at night, the day man would say the same thing about the night man.

After I had been there a few days and explained to the manager how the scale formed, he saw that the water was more to blame than the men. We then decided to try some boiler compound, which we did without getting good results.

Relative to compounds I would state that I regard as useless those that separate the foreign matter from the water in the boiler, as it throws down the impurities on the boilers, and the trouble continues just the same. The water should be treated before going into the boilers; not after entering them. The best thing we used in this case was coal oil, half a gallon every 24 hr., per 100 hp., feeding it through the suction pipe of one pump, using a sight-feed drip valve to get a uniform feed. I do not contend that this will apply to all cases, but we got good results. One must experiment and watch results to find the best remedy.

W. A. LEE.

Sorrento, La.

Correcting Trouble of Pilot Piston

While I was on duty on a coastwise steamer, we fitted a new steam chest to the independent vacuum pump, but when we turned steam on we found that the pilot piston struck the heads of its chamber, instead of cushioning as it should. Upon taking the heads of the pilot-piston chamber off we discovered that the small check valves in the steam ports did not seat and permitted the steam to exhaust through the admission port, which left no steam in the chamber for the pilot piston to cushion on. After repairing the check valves (in this case they were simply brass flaps over the admission port) the pump ran noiselessly.

ALFORD H. SMITH.

Rogers, Ark.

Sand Cuts Pump Rods and Packing

While working in a certain plant, we experienced much trouble from the cutting out of the packing in our boiler-feed pumps, the plungers of which were outside packed. We tried flax, canvas and a few well known pump packings, but it got so they would cut out in a few days. Determined to find the cause, I removed the air chamber and cover plate from the water end and discovered a large quantity of sand between the valve decks, which sand had been drawn from the surge tank.

To offset this trouble from sand, the suction pipe was extended up through the bottom of the tank for about 1 ft. Every day the sand was blown out from a blow-down pipe in the bottom of the tank, at one end. No further trouble was experienced with the packing cutting out.

C. E. SKELLEY.

Chicago, Ill.

Dry Air Pump as Air Compressor

The use of compressed air in most modern power houses for cleaning has become almost a necessity. The wiring and contacts on a remote control switchboard cannot be effectively rid of accumulations of dust and dirt by any other means, and to attempt to wipe them off, while in operation, would not only be futile, but dangerous. The hand bellows, besides not giving sufficient blast, is an unhandy, not to say impossible thing with which to clean circuit-breakers, oil switches, and other adjuncts of a modern board, which, in plants running 24 hr., must be cleaned while in operation.

Compressed air is not always available at power houses, for consulting engineers, as a rule, do not yet appreciate that a small air compressor is a very desirable addition to the power-plant equipment.

In one plant, where the dust problem is serious, the engineer obtained air by temporarily converting the dry-vacuum

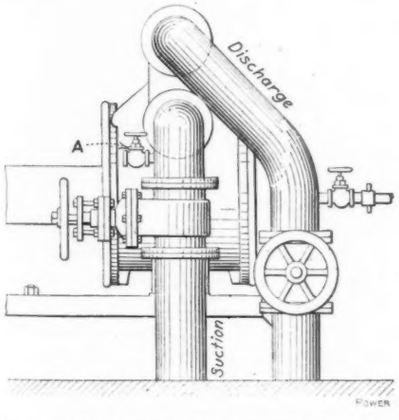


FIG. 1. SHOWING CONNECTIONS FOR CONVERTING AIR PUMP INTO AIR COMPRESSOR

pump into an air compressor. Fig. 1 shows how simply this was done. Both the suction and discharge pipes have gate valves in the positions shown. Above the valves, the pipe was drilled and tapped for 1¼-in. connections, putting a valve on each as shown.

When it is desired to use it as an air compressor, both large valves are closed, and the air is taken in at *A*, and the hose is connected at the small valve on the discharge line. This gives us a blast of dry air sufficiently strong to dislodge any dirt that may collect. As there are duplicate units, one machine is usually available, although recently, while both were in operation, the pump was cut off from the condenser for a few minutes and used for cleaning, the vacuum meanwhile falling, slowly, from 28 in. to 10

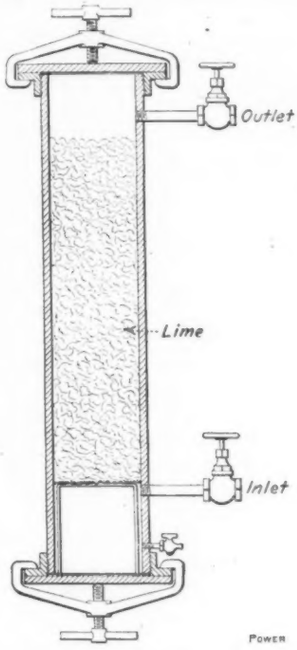


FIG. 2. DRYER FOR ABSORBING MOISTURE FROM AIR

in., when the blowing was stopped, the large valves were opened, and the vacuum again raised to normal. The valve *A* is also used as a vacuum breaker when the main units are operating condensing.

When using compressed air for cleaning electrical apparatus, one should be sure the air is dry, and that no slugs of water can be picked up anywhere in the line and carried along. Such a happening might result in serious damage. When the air is taken from a general line supplying air for industrial purposes, an air dryer or moisture collector should always be used. A form of dryer which is easily constructed, and will give good results, is shown in Fig. 2. A piece of large diameter wrought-iron pipe, preferably 12 in., and about 4 to 6 ft. long, is drilled and tapped at each end, as shown, for ¾-in. pipe (which size will give ample blast for any purpose); a bolted flange or a clamp may be used to close the ends of the 12-in. pipe. At the lower end of the pipe, a piece of heavy screen should be placed about 6 in. from the bottom. The pipe should be filled to within a foot of the top with lime, and the flange clamped on tight. This will absorb all the moisture and leave the air dry.

In blowing out apparatus, it is well to remember that damage can be done by the careless use of an air blast; insulation can be loosened, and the wires in small resistance coils might easily be disarranged and possibly short circuited resulting in much trouble.

Finally, the hose used should not be wire-wound, or terminate in a metal nozzle or coupling.

S. M. QUINN.

Hudson, N. Y.

Queer Feat of Cylinder Head

Some years ago I was employed on a side-wheel steamboat of the beam-engine type. We had been taken off our run to make some repairs, of which the most important was reboring the cylinder. It was 63 in. in diameter and 11-ft. long.

We had opened and washed the boilers, and the drips to the cylinder were also opened. Lifting the cylinder head was done by putting the crank on the lower center and then lashing the wheels so the engine could not turn either way. By using large tackles from the crosshead to the cylinder head the latter was lifted. We had started to lift the head and before we had much more than got a strain on the tackles, the cylinder head jumped up about 3 in. and then dropped back onto the cylinder. There was a flat rubber gasket on the cylinder head.

Those who have had experiences on engines like this will remember that the cylinder head is very heavy and not easy to lift. I would like to have readers give their opinion as to why the head jumped off in this manner.

CLARENCE R. DAVIS.

East Boston, Mass.

Boiler Explosion in New Zealand

I notice in POWER many accounts of boiler explosions. Boiler explosions here in New Zealand are practically unknown. In this country every boiler must be examined by an inspector once a year. If the boiler is passed, he gives the owner a certificate, which shows the amount of pressure the boiler is allowed to carry. This certificate must be placed in the boiler room. Every boiler over 15 hp. and also engine with cylinders of 144 circ.in. up to 200 circ.in. must be in charge of a second-class certified engineer. Every engine with a cylinder of 200 circ.in. or over, with boiler attached must be in charge of a first-class certified engineer.

Any person found tampering with the safety valve to make the boiler carry more pressure than allowed by the certificate, is liable to lose his certificate or to a heavy fine. The inspectors are appointed by the government.

FREDERICK W. KIRBY.

Auckland, N. Z.

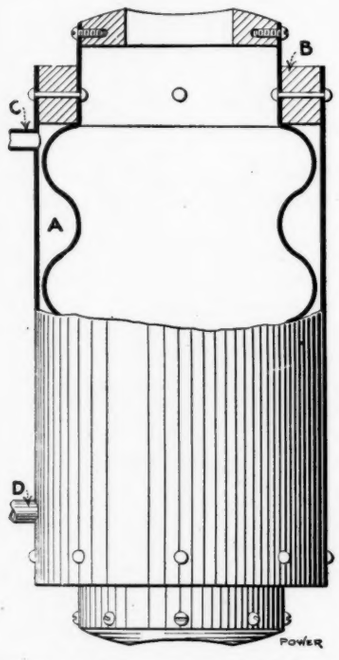
Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Design of High-Pressure Tank

On re-reading the issue of Apr. 9, I was interested in the article "Exploding Tank Wrecks Building," page 506. It is a good description of what a faulty rendering tank can do in the way of destruction. I have made, patented and used for many months a tank unique for its simplicity of design and ability to withstand hard usage.

This rendering tank consists of an outer and inner shell, the latter being corrugated as shown; the steam space is at *A*. Between the shells at each end is placed a ring *B* to which both shells



SHOWING SECTION OF NEW DESIGN RENDERING TANK

are riveted. The steam inlet is shown at *C* and the outlet at *D*. The inner shell has a manhole at each end.

The corrugated shell is first made by welding the edges instead of riveting them, which gives full efficiency to the joint. Then the corrugations are rolled at white heat, and the strength exceeds many times the pressure required for rendering. The surface is free from such nuisance as stay-bolts, seams, or places where the animal acid can attack.

The usual size jacketed tank is about 9 ft. high by 30 in. internal diameter and has stay-bolts every 6 in. of inside surface, or about 225 bolts in all, any one of which may begin to leak after three years' steady use. This is due to cold heading of the stays.

H. F. BREHM.

Waterloo, N. Y.

Graphite in Boilers

I read with much interest your editorial in the issue of Sept. 17 entitled "Graphite in Boilers," as yours is the first real mention that has come to my notice on this subject.

We have been using graphite in our boilers for the past 18 months with very gratifying results. We started its use by putting about two quarts of the commercial flake graphite into each boiler when it was cleaned. While this was successful in loosening a small amount of scale, it was rather slow. Consequently, about Nov. 1, 1911, we commenced using a regular boiler graphite.

This finely powdered graphite was introduced into the boiler water in the following manner: We tapped the boiler feed line on the pump side, screwed in a short length of ¾-in. pipe fitted with a globe valve and a large (one pint) oil cup. The cup is filled with graphite, the valve opened and the pump does the rest. As soon as all the graphite has been drawn into the line, the valve is again closed.

We have four 250-hp. water-tube boilers operating at 125 lb. pressure. Three of them are in constant operation with the fourth for reserve. These boilers were second-hand when installed by us and contained about ⅛ in. of hard scale. Immediately after cleaning each boiler, we throw into it about two quarts, or, say 3 lb. of graphite. Then we daily introduce with the feed water about one pint of graphite to each 100 hp. The boilers are blown down twice daily, the morning shift blowing from the bottom and the afternoon shift blowing from the top.

At present almost all the old scale has come off, while that remaining is loose and in a short time will all come off and the boilers will be perfectly clean. After the boiler has become clean the graphite circulates with the water against the metal to which it imparts a graphite finish or polish.

The action of graphite in neutralizing scale-forming contents, or in loosening old scale is, I consider, purely a mechanical one. It prevents the scale-forming content of the water from adhering to the metal by mixing with it and forming a sludge which drops to the bottom of the boiler and is easily washed out. As to its action on the old scale, the finely powdered graphite works its way into all the small cracks and interstices of the scale, weakens it, and destroys its adhesion to the metal.

While the action of the graphite is, perhaps, somewhat slower than that of chemical compounds, yet this disadvantage is more than counteracted in its following advantages:

Its action being a mechanical one it can be used successfully with any feed water, i.e., it is not necessary to have a compound made up for each kind of feed water. Being insoluble it cannot pass out with the steam and thereby unfit it for certain industrial purposes, as for instance, in breweries, laundries, ice plants, etc., as is frequently the case where compounds are used. It acts mechanically and not chemically and can in no way injure the boiler. It is also cheap, costing only about 3c. per 100 hp. per day.

J. M. BURNS.

Dover, N. J.

While working as boiler washer in a plant containing six 250-hp. water-tube boilers, we washed out and removed all the scale from the tubes and drums six weeks. After the tubes and drums had been cleaned and the tube caps replaced, about 5 lb. of flake graphite was placed in each drum, the manhole plates replaced, the boiler filled, tested and put in service.

When a boiler was opened for cleaning and the cleaner run through the tubes, large pieces of scale would come off, leaving the metal clean. Upon examining pieces of scale, the flakes of graphite could be plainly seen on the under side. This prevented it adhering tightly to the metal. The same conditions prevailed in the drums.

I cannot speak on graphite scale-preventing qualities, but I do know that it makes much easier the removal of scale already formed.

FRED L. WAGNER.

Chicago, Ill.

We have a plant of four water-tube boilers; one 200 hp. and three 250 hp. each. We were using lake water which makes

a hard scale, and tried numerous compounds with various degrees of success; finally we tried graphite compound. It prevented the scale getting hard, loosened the old scale and left the boilers perfectly clean.

But our water bill was excessive so the firm laid a line to a small stream near the plant and pumped the water into a storage tank. Then our troubles began; the water was surface water and the greater part of it came from a large brick yard.

The boilers began to scale heavily. We increased the graphite and it had no effect unless to make the scale harder, for it was the hardest scale I ever saw; it would take from three to five days to clean a boiler with a turbine cleaner.

Then we began to lose tubes—as many as 15 tubes in one month. This was too expensive, so we had a sample of the water analyzed and a compound made to counteract the scale-forming properties. It is giving excellent results as we have not lost one tube since we began using the compound. But I have tried the same compound in other plants with poor results. So I find it is with graphite as with other compounds, what will give good results in one plant may be detrimental to another.

WILLIAM J. AU.

Cleveland, Ohio.

Zinc as Corrosion Preventive

Mr. Stafford in the Oct. 1 issue asks how zinc slabs should be used to prevent corrosion.

While employed as a boiler inspector I made a trip through Oklahoma in the place of the district inspector. At one plant I met with a very enthusiastic reception. The previous inspector had advised the use of zinc slabs suspended in the boiler to counteract the pitting effect of sulphuric acid in the feed water which was partly mine water. The engineer at the plant religously followed the inspector's advice as to how the slabs should be suspended from the through rods below the tubes (the boilers were of the horizontal tubular type), however, he neglected to comply with the additional instructions to place a pan made of sheet iron underneath the suspended zinc.

The plan worked well; the acid attacked the zinc with a vengeance, the result being that the zinc disintegrated and fell to the bottom of the boiler in a pile and soon after there was a bag in the fire sheet, which came down like an elongated cocoanut, necessitating a patch about 12x20 in., right where a patch should not be. Naturally, the superintendent felt like welcoming boiler inspectors in the true Western fashion of welcoming horse thieves.

In Mr. Stafford's case he proposes to treat a marine boiler in which the danger of burning a sheet would be practically nil, provided he does not suspend the zinc directly over the furnace. The corrosion in his case is most likely caused by the returns from the heating system, which become so purified by continued condensation that they have a corrosive action.

A. C. TERLENE.

Chattanooga, Tenn.

Relative to Mr. Stafford's inquiry concerning the placing of zinc slabs in boilers to prevent pitting, it does not make so much difference how the zinc is suspended so long as it does its work—whether hung from a hook or otherwise I have found the best way, for general convenience in cleaning out and making renewals, to be to construct a pan of ⅛-in. iron, any size to suit the conditions and shape of the braces, and suspend it from the braces so it will clear the top row of tubes by 2 or 3 in. Turn up the edges of the pan not less than 2 in. and drill a number of small holes in the bottom. In a few weeks, depending on the acidity of the water, the zinc will have pulverized and become like gravel—depending on the amount of dross in it.

If the back end of tubes and shell show most pitting, hang the basket or pan at that end; if the front end is most affected, put it there.

H. A. WYCKOFF.

Brooklyn, N. Y.

The following is the method in which zinc is used to prevent pitting of the boilers aboard Uncle Sam's battleships:

An iron box is made of ¼-in. material, 12 in. wide by 40 in. long, and 13 in. deep. Large holes are cut in the sides and bottom, and the top is left open. This is suspended from the shell of the steam drum and comes just below the water line. In this box are placed 18 slabs of zinc, each 12x12x½ in.—set six in a row. The zinc weighs 446 lb. per cu.ft., or about 18.5 lb. to each slab, making a total of about 333 lb. in each boiler. These slabs are set on edge in the box with holes drilled in them and through the box, through which ½-in. rods are run with large nuts or washers between the slabs to hold them in place and about 1¼ in. apart. The rods have a split pin through the end to keep them in place. This arrangement exposes the greatest surface of zinc to the action of the water which passes through the holes in the box and around the plates of zinc. The action of the water on these slabs causes them to waste away, but when they are taken out there is a coating of scale on them which often entirely fills up the space between the slabs. This scale is easily cracked off when dry, and leaves the slabs about one-quarter or one-half their original thickness. These slabs, if too thin, are not used again.

The water used in the boilers of these ships, although coming from the evaporators, is more or less salty and contains chemicals that cause galvanic action and pitting. When zinc is used the galvanic action takes place on the zinc instead of on the boiler, as zinc has a stronger attraction for the acids than the iron.

In one battleship there are 16 water-tube boilers with a total of 29,000 hp., or 1812 hp. each. Each boiler has one box of these zinc plates. I should judge that 10 to 15 lb. of zinc slabs suspended in the drum just below the water line, or about 7 lb. per 100 boiler-hp. would be sufficient for a stationary boiler.

J. C. HAWKINS.

Hyattsville, Md.

I would advise Mr. Stafford that zinc will prevent incrustation as well as corrosion in boilers. The scale may acquire thickness and hardness, but can easily be removed from the plates. It is supposed that the zinc in connection with the iron plates keeps up a feeble galvanic action and that the hydrogen liberated at the surface of the plate by this action prevents the incrustation from adhering to it.

The zinc should be thoroughly distributed throughout the boiler in the form of slabs. About 1 sq.in. of zinc surface should be supplied for every 50 lb. of water.

FRANK BYUS.

Norborne, Mo.

Pitting is perhaps the worst kind of boiler corrosion. Pit holes range from the size of a pin head to the size of a dime or more and are conical or cup-shaped. The depth of these pits may be anything from a slight depression to a hole cut through the shell or tube. They are not found in any fixed place, although they are more commonly found on the tubes, furnaces and the combustion chambers of Scotch boilers than any other place. They are generally filled with a black pasty mass, which is chiefly iron oxide, lime salts and oily matter.

To account for the formation of these pits, various explanations have been suggested, most of them claiming electrochemical action as the cause. It is claimed that all substances are at a different electrical potential or pressure. This difference is found not only between substances of different kinds, but also between similar substances at different temperatures or in different physical conditions, as, for example, between two pieces of iron or steel, one of which has been hammered or worked more than the other. Due to this difference of potential there is a tendency to set up a flow of electric current from one to the other, and to change the two substances so as to bring them into electrical equilibrium or balance.

These chemical changes may be much accelerated or retarded by the medium in which the bodies are immersed. If they are in dry air, for instance, no activity takes place, and the difference of electrical conditions remains unchanged. If they are immersed in water, or especially in salt or slightly acid water, the operation will usually be greatly assisted by the medium.

In a boiler the continued electro-chemical action occurs for a variety of reasons. Parts of the boiler of widely differing temperatures or of different physical or chemical compositions may provide the elements which are at different electrical potential. Such a difference is likely to be found between iron and its oxides, especially the magnetic oxide or mill scale or between a particle of carbon in the steel and the surrounding metal, or between a place in the steel where the proportion of carbon is much greater than the average or in the surrounding metal, or between a bit of slag or other impurity in wrought iron and the adjacent metal.

What is needed is a substance which will be electro-positive to iron and readily attacked, so that the wasting away will be diverted from the iron to this protecting substance, and the operation will proceed at the expense of this substance instead of the boiler. Such a substance is zinc, and its use for this purpose is beneficial.

The zinc must be in actual metallic contact with the boiler. The best zinc to use is the rolled variety of close grain and uniform structure, free from impurities. I have found that the number of zinc slabs 12x8x⅝ in. required for the thorough preservation of boilers is about one for every 50 sq.ft. of tube surface, that is approximately equal to

$$\frac{N \times D \times L}{197}$$

where

N = Number of tubes plus the number of solid stays;

L = Length between the tube plates or sheets in feet;

D = External diameter of the tube in inches.

This method is used by the U. S. Government. Another rule often used is 12 lb. of zinc to every 25 indicated horsepower.

Care should be taken in placing the zincs so that there are enough near the water line and the combustion-chamber tops and about one-sixth of the total number should be placed in the steam space.

Upon examining the zincs in the boiler after they have been in use for some time, it will be noticed that the wear or action on the zinc is entirely confined to its surface.

C. E. ANDERSON.

Chicago, Ill.

Distribution of Power in the United States

The tables from the U. S. census report on manufacturing industries submitted by Mr. Tuck and published in the Oct. 15 issue are interesting, but it should be noted that they give only the distributed horsepower in the manufacturing plants and that two important branches, electric-railway power stations and central power plants, are not included.

POWER readers may be interested in more complete information on this subject, which goes a step further than the tables submitted by Mr. Tuck. My composite table necessitated going through many government reports and other sources of information and the main table gives 35 different items under each state.

Inasmuch as the census reports on central stations and electric railways were issued in 1902 and in 1907, while the census reports on manufacturing industries were issued in 1904 and 1909, it was found necessary to group the 1902 and 1904 reports and compare them with the 1907 and 1909. As most readers are interested mainly in the amount of power generated in steam-power plants, I only include the summary covering that branch, omitting plants using water power, gas engines and purchased electrical power.

This summary shows that in 1902 and 1904, 80 per cent. of the horsepower of the steam-power plants was installed in private plants in the manufacturing industries, while in 1907 and 1909, only 74 per cent. of the total amount of power was generated in these plants. This corroborates Mr. Tuck's statement that manufacturers are buying more power than formerly and that the central stations are becoming more important. Central-station activity is further apparent by considering the third column of Table 1, which shows that during five years central stations increased their power installations by 92 per cent. while manufacturing plants increased only 32.4 per cent.

Some of the information developed is extremely interesting and has shown where to look for new business. For instance, in the five years covered by the report, the table shows only a 15 per cent. increase in the total amount of steam power-plant apparatus installed in Massachusetts, while Wisconsin has a 129 per cent. increase. Many other surprises were brought out that show where-in it was necessary to revise some of our selling plans in order to take advantage of natural tendencies.

While, as Mr. Tuck points out, there has been quite an increase in the gas-engine business in some parts of the country, this item is not of so much importance when it is reduced to its proper proportion, as will be made clear by referring to Table 2.

Table 2 shows that, while in the five years covered by the tables the steam horsepower has increased only 42.5 per cent. and the gas-engine horsepower 173 per cent., when figured out on the proportion that each of these items is of the total, as given in the last column, only 3.5 per cent. of the total horsepower in the United States is in gas-engine installations.

TABLE 1.—SUMMARY OF STEAM POWER

	Hp. 1902–04	Hp. 1907–09	Per cent. inclusive in 5 yr.	Per cent. of total 1902–4	Per cent. of total 1907–09
Manufacturing	10,813,044	14,202,142	31.4	80.2	74.0
Light and power central stations	1,369,155	2,627,450	92.0	10.2	13.7
Electric railway power stations	1,298,133	2,368,183	82.5	9.6	12.3
Totals	13,480,332	19,197,775	42.5	100.0	100.0

TABLE 2.—SUMMARY OF TOTAL POWER

	1902–04	1907–09	Per cent. increase in 5 yr.	Per cent. that increase is of total inc.	1902–04	Per cent. distribution 1907–09
Steam horsepower	13,480,332	19,197,775	42.5	77.7	84.6	82.5
Number of units	135,533	163,199	21	65.4	75.4	73.6
Gas-engine horsepower	303,529	826,246	173	7.1	1.9	3.5
Number of units	21,695	34,856	61	31.1	12.1	15.6
Water horsepower	2,135,505	3,263,822	53	15.2	13.5	14.0
Number of units	22,451	24,038	7	3.5	12.5	10.8
Total horsepower	15,919,366	23,287,853	46	100.0	100.0	100.0
Total Number of units	179,769	222,093	24	100.0	100.0	100.0

GEORGE H. GIBSON.

New York City.

The first steel produced in this country was probably made in Connecticut in 1728 by Samuel Higley and Joseph Dewey, according to the U. S. Geological Survey.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Varying Voltage of Converters

What commercial methods are employed for varying the direct-current voltage of a rotary converter?

T. W.

Using (1) an alternating-current synchronous booster, (2) an alternating-current potential regulator, (3) a direct-current booster, (4) a split-pole converter, or (5) by automatic compounding.

Idler Pulleys

Are idler pulleys which run on the opposite side of the belt from the transmission pulleys, usually made with straight or crown face, and why?

W. M. F.

Idler pulleys regardless of the side of belt on which they are used are generally made crown faced to urge the belt to travel symmetrically with the idler. When a tightener-idler is used for increasing the arc of contact of a belt on a transmission pulley the face of the idler is generally less crowned than the crowning commonly given to faces of transmission pulleys.

Preventing Motor Runaway

What prevents a shunt-wound motor from running away when the load is suddenly taken off?

J. B.

The armature winding, in cutting the magnetic lines of the field, generates an electromotive force opposite to that which forces the current through the armature. As the motor tends to speed up, the counter electromotive force tends to increase and thus automatically prevents a rush of current through the armature. In this way the speed is kept down to a value very little in excess of that at full load.

Cracks in Boiler Side Walls

Can the side walls of ordinary return-tubular boiler settings be constructed so they will not crack, and if not, what precautions can be taken in their construction to minimize their cracking?

A. H.

As the linings of a boiler setting are subjected to high temperatures, cracks in the side walls resulting from expansion of the brickwork are practically unavoidable. Side walls which remain freest from through cracks are those which are carefully laid up with an air space and ample expansion space, filled with asbestos or mineral wool, between the boiler and the brickwork, except where supporting side-brackets rest on the walls.

Stop Diagram

What is a stop indicator diagram and why is one taken from a gas engine?

D. R.

A stop diagram is one in which the recording pencil of the indicator by stopping at the limit of its travel, is thereby prevented from indicating cylinder pressures which exceed the limit of pressure so recorded. Stop indicator diagrams are taken of gas engines by using a weak indicator spring to obtain a diagram which will more clearly show events during the exhaust and suction strokes in a four-stroke-cycle gas engine regardless of greater pressures which are beyond the range of measurement by the indicator spring thus used.

Formula for Shafting

What is the rule for estimating the safe number of horsepower transmitted by iron or steel shafting when properly lined up and supported?

A. F.

The safe-transmitting capacity of a $1\frac{15}{16}$- or nominal 2-in. diameter shaft, with the usual bending strains of pulleys, belts, etc., is 10 hp. at 100 r.p.m. The torsional resistances of shafts are as the cubes of their diameters, and the number of horsepower transmitted by any given size is directly in proportion to its speed of rotation. Hence for finding the power capable of being transmitted by any size shaft at any number of revolutions per minute: Multiply the cube of its diameter in inches by the revolutions per minute and by 10 and divide by the cube of 2, multiplied by 100; or expressed in a formula wherein

d = Diameter of shaft;
n = Number of revolutions per minute;

$$\frac{d^3 \times n \times 10}{2 \times 2 \times 2 \times 100} \text{ or } \frac{d^3 n}{80} = horsepower$$

As an example, the safe number or horsepower which a 3-in. shaft, running at 200 r.p.m., could transmit would be

$$\frac{(3 \times 3 \times 3) \times 200}{80} = 67.5\ hp.$$

Small Loss of Head

What pressure per square inch would be lost in overcoming pipe friction to pump water at the rate of 500 gal. per hr. through a 6-in. pipe, 2500 ft. long?

A. J. H.

The cross-sectional area of a 6-in. diameter pipe being 28.274 sq.in., and as 500 gal. would be $500 \times 231 = 115{,}500$ cu.in., the velocity of flow in the pipe would be

$$\frac{115{,}500}{28.274 \times 60 \times 60 \times 12} = 0.094+\ ft.\ per\ sec.$$

or practically only about 0.1 ft. per sec. By Darcy's formula the loss of head from friction would be, in feet,

$$h = \left(0.0199 + \frac{0.00167}{d}\right) \times \frac{l}{d} \times \frac{v^2}{2g}$$

in which d, l and v are respectively the diameter and length of pipe and the velocity of flow per second all given in feet, and g is the acceleration of gravity (equal to 32.162 ft. per sec.) Substituting in the formula the values

$l = 2500$ ft.; $d = 0.5$ ft.;
$v = 0.1$ ft.; $2g = 64.324$;

$$h = \left(0.0199 + \frac{0.00167}{0.5}\right) \times \frac{2500}{0.5} \times \frac{0.1 \times 0.1}{64.324}$$

$$\text{or, } h = 0.02324 \times \frac{25}{32.162} = 0.018\ ft.$$

is the head lost in friction, which would amount to $0.018 \times 0.433 = 0.0078$ lb. per square inch, showing that in pumping through a 6-in. pipe, at the rate of flow stated, the loss of pressure from friction would be practically zero.

Raising Sheet Iron Stack

What is the best method of raising or lowering a sheet-iron smoke-stack 60 ft. high and 3 ft. in diameter?

L. C. F.

The best method is to use a block and fall and gin pole. It will generally be safer to erect or lower such a stack in two or more sections of length, for which purpose each section should have lashed to it a number of equally spaced staves for receiving a rope sling for suspending the weight of the section a little above its center of gravity. Suspended in this manner the position of a section is readily controlled and the staves will prevent crushing of the section at its point of suspension. An illustrated article describing the method of erecting a 90-ft. stack appeared in the Mar. 8, 1910, issue of POWER, pages 435-437.

Engineers' Study Course—III

Multiplying the numerator multiplies the fraction.

It is easy to see that five of the subdivisions, or $\frac{5}{12}$ of the circle in Fig. 1 is five times as much as one subdivision, or that

$$\tfrac{5}{12} = 5 \times \tfrac{1}{12}$$

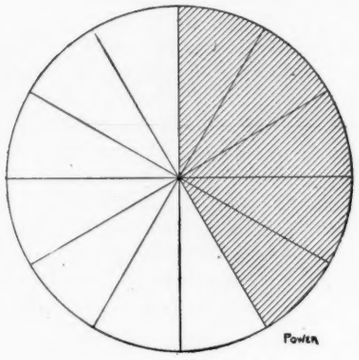


FIG. 1

EXAMPLE: The diameter *AB*, Fig. 3, is 24 in. Along this diameter are 12 holes, each ¾ of an inch in diameter. How much solid plate is there left on the section *AB*?

$$12 \times \tfrac{3}{4} = \frac{12 \times 3}{4} = \tfrac{36}{4} = 9 \text{ in.}$$

Applying what we have just learned about cancellation, we can do this still more easily, as follows:

$$\frac{\overset{3}{\cancel{12}} \times 3}{\underset{1}{\cancel{4}}} = 9$$

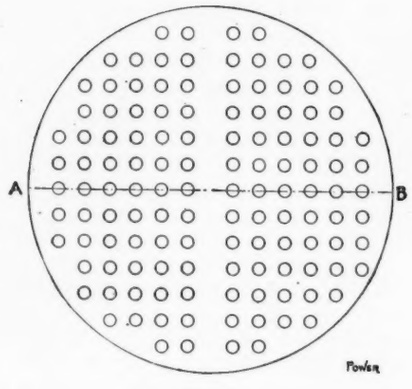


FIG. 3

If 9 in. are taken up by the tubes, there will be

$$24 - 9 = 15 \text{ in.}$$

of solid plate.

EXAMPLE: The area of the circular head, of which *AB*, Fig. 3, is the diameter, is $3\frac{14}{100}$ sq.ft. There are in it 125 tubes, each having a cross-sectional area of $\frac{11}{25}$ of a square inch. How many square inches of head remain?

The area occupied by the tubes is

$$125 \times \tfrac{11}{25} = \frac{125 \times 11}{25} = \tfrac{1375}{25} = 55 \text{ sq.in.}$$

The area of the head is $3\frac{14}{100}$ sq.ft. The difference between $3\frac{14}{100}$ sq.ft. and 55 sq.in. will be the area of the head.

But one cannot subtract square inches from square feet directly.

$$88 \text{ sq.ft.} - 16 \text{ sq. in.} = 72 \text{ what?}$$

Before quantities can be added or subtracted they must be reduced to the same terms. Feet must be subtracted from feet, inches from inches, etc. You cannot take six barrels of pears from 12 barrels of apples and have six barrels of something left, but you can take six barrels of fruit from 12 barrels of fruit and have six barrels of fruit left, because you have reduced it to fruit, a term common to both kinds of article involved.

In 1 sq.ft. there are 144 sq.in.

$$3\tfrac{14}{100} \text{ sq.ft.} = \tfrac{314}{100} \text{ sq.ft.}$$

In $3\frac{14}{100}$ sq.ft. there are

$$144 \times 3\tfrac{14}{100} = 144 \times \tfrac{314}{100} = \frac{144 \times 314}{100}$$

$$= 452\tfrac{16}{100} \text{ sq.in.}$$

From this we can now take the 55 sq.in. occupied by the tubes, leaving

$$452\tfrac{16}{100} - 55 = 397\tfrac{16}{100} \text{ sq in.}$$

in the rest of the head.

Get that idea clearly that things must be reduced to the same *denomination*, before you can add or subtract them. We shall need to use it again in the next lesson.

Dividing the denominator multiplies the fraction.

Notice that? Dividing the denominator does the same thing to a fraction that multiplying its numerator does.

The value of a fraction is the quotient found by dividing the numerator by the denominator. The smaller the divisor or denominator the greater the quotient. If the divisor or denominator is only one-half as great, the quotient or value of the fraction will be twice as large. If the denominator is only one-third as great, the value will be three times as large, etc.

$\frac{16}{8} = 2$ but $\frac{16}{4} = 4$ (twice as much)

$\frac{60}{18} = 4$ but $\frac{60}{6} = 12$ (3 times as much)

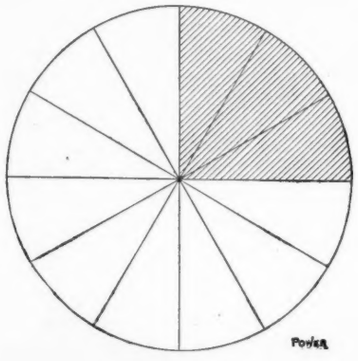


FIG. 4

In Fig. 4 the circle is divided by the horizontal and vertical lines into four equal parts. Each of these is divided into three equal parts. If we write $\frac{3}{12}$, it will denote only the shaded part of the circle, i.e., three of the smaller divisions. (These *smaller* divisions are denoted by the *larger* number 12, because the *more* portions we divide the circle into the *less* each portion becomes.) But if we write ¾ it will denote the larger unshaded part of the circle three times as large as the shaded portion. The numerator is the same in both cases, but in one case, we have three of the smaller divisions, $\frac{1}{12}$ths, and in the latter case three of the larger divisions, ¼ths.

Dividing the numerator divides the fraction.

One-half of eight apples is four apples. It is equally easy to see that one-half of eight "ninths" or $\frac{8}{9}$ is four "ninths" or $\frac{4}{9}$.

Multiplying the denominator divides the fraction.

Applying the same reasoning that we used to show that dividing the denominator multiplied the fraction, it is easy to see that multiplying the denominator divides the fraction. A look at your rule will show that $\frac{3}{16}$ is only one-half as much as $\frac{3}{8}$. By multiplying the denominator by 2 you have divided the value of the fraction by 2.

In some examples previously given we multiplied fractions by integers or whole numbers. Suppose we want to find what three-quarters, or ¾ of 12 is.

One-quarter of 12 is $\frac{12}{4} = 3$, then three-quarters of 12 are $3 \times 3 = 9$, or doing the whole thing together

$$\frac{3 \times 12}{4} = 9$$

We have *divided* the quantity which was to be multiplied, by the denominator of the fraction and *multiplied* by the numerator.

Now suppose we wanted to find ¾ of $\frac{9}{16}$, that is, to multiply $\frac{9}{16}$ by ¾. We simply do the same thing. We *divide* $\frac{9}{16}$, the quantity to be multiplied, by the denominator of the fraction by which we want to multiply it, by multiplying its denominator by the denominator of the multiplier, and then we multiply it by multiplying its numerator by the numerator of the multiplier.

$$\tfrac{9}{16} \times \tfrac{3}{4} = \frac{9 \times 3}{16 \times 4} = \tfrac{27}{64}$$

The rule for multiplying fractions turns out to be very simple. I could have

given it to you without so much explanation, but I want you to understand the reason for it, as these reasons will be of constant use in understanding what is coming.

To Multiply Fractions

Rule: *Multiply all the numerators together for the new numerator.*

Multiply all the denominators together for a new denominator.

Example: An engine developing 24⅔ hp. takes 5⅙ lb. of coal per hour per horsepower. How much coal would it take to run it three-quarters of an hour?

$$24\tfrac{2}{3}\ hp. = \frac{3 \times 24 + 2}{3} = \tfrac{74}{3}\ hp.$$

$$5\tfrac{1}{6}\ lb. = \frac{6 \times 5 + 1}{6} = \tfrac{31}{6}\ lb.$$

$$\frac{74}{3}\ hp. \times \frac{31}{6}\ lb. \times \frac{3}{4}\ hr. = \frac{74 \times 31 \times 3}{3 \times 6 \times 4} = \frac{1147}{12} = 95\tfrac{7}{12}$$

Suppose we wanted to *divide* 12 by ¾.

Division is just the opposite of multiplication. When we *multiplied* 12 by ¾ we divided it by 4 (the denominator) and multiplied by 3 (the numerator).

To *divide* it by ¾ we multiply it by the denominator and divide by the numerator.

This simply means that you tip the divisor fraction upside down, and multiply the quantity to be divided by its denominator, and divide it by its numerator.

$$12 \div \tfrac{3}{4} = 12 \times \tfrac{4}{3} = \frac{12 \times 4}{3} = 16$$

$$\tfrac{11}{16} \div \tfrac{3}{8} = \tfrac{11}{16} \times \tfrac{8}{3} = \tfrac{88}{48} = 1\tfrac{40}{48}$$

When the quantity to be divided is a whole number it may be treated as an improper fraction, the denominator of which is 1, so that we could say

$$\tfrac{12}{1} \div \tfrac{3}{4} = \tfrac{12}{1} \times \tfrac{4}{3} = 16$$

To Divide by a Fraction

Rule: *Invert the divisor and proceed as in multiplication.*

Example: A stuffing-box is 4½ in. deep. How many rings of packing, each ¾ in. wide, will it take to fill it?

$$4\tfrac{1}{2}\ in. = \frac{2 \times 4 + 1}{2} = \tfrac{9}{2}\ in.$$

$$\tfrac{9}{2} \div \tfrac{3}{4} = \tfrac{9}{2} \times \tfrac{4}{3} = \tfrac{36}{6} = 6\ rings$$

I told you that a simpler way to indicate division than by the use of the division sign ÷ is to write the dividend above the line and the divisor below. This applies to fractions as well as to whole numbers.

Instead of $\frac{9}{2} \div \frac{3}{4}$, we may write $\frac{\frac{9}{2}}{\frac{3}{4}}$.

When you have a fraction above the line drop its denominator below the line with a multiplication sign. This will simplify matters and will not change the value of the expression

$$\tfrac{3}{4} \div 2 = \tfrac{3}{8} \qquad \frac{\frac{3}{4}}{2} = \frac{3}{2 \times 4} = \tfrac{3}{8}$$

When you have a fraction below the line, change its denominator to a multiplier above the line. For instance, in the above example about packing we could write

$$\frac{\frac{9}{2}}{\frac{3}{4}} = \frac{9 \times 4}{2 \times 3} = \tfrac{36}{6} = 6$$

This amounts to the same thing as the rule given but is simpler. Remember, that it is always the denominator whose position is changed and that it becomes a multiplier in both cases.

Let us try one final example involving both multiplication and division.

Example: A boiler evaporates 9¼ lb. of water per pound of coal and the engine uses 25⅛ lb. of steam per hour per horsepower. How many pounds of coal will it take to run the engine for a week of 5⅓ days of 9¾ hours each with a load of 246⅔ hp.?

The engine will take

25⅛ × 246⅔ lb. of steam per hour

25⅛ × 246⅔ × 9¾ lb. of steam per day

25⅛ × 246⅔ × 9¾ × 5⅓ lb. of steam per week

If 1 lb. of coal makes 9¼ lb. of steam, it will take as many pounds of coal to run the engine a week as 9¼ is contained times in the above product; so that the whole problem reduces to

$$\frac{25\frac{1}{8} \times 246\frac{2}{3} \times 9\frac{3}{4} \times 5\frac{1}{3}}{9\frac{1}{4}}$$

Reduce these mixed numbers all to improper fractions

$$25\tfrac{1}{8} = \frac{8 \times 25 + 1}{8} = \tfrac{201}{8}$$

$$246\tfrac{2}{3} = \frac{3 \times 246 + 2}{3} = \tfrac{740}{3}$$

$$9\tfrac{3}{4} = \frac{4 \times 9 + 3}{4} = \tfrac{39}{4}$$

$$5\tfrac{1}{3} = \frac{3 \times 5 + 1}{3} = \tfrac{16}{3}$$

$$9\tfrac{1}{4} = \frac{4 \times 9 + 1}{4} = \tfrac{37}{4}$$

Substituting these figures in the above statement of the problem, we get

$$\frac{\frac{201}{8} \times \frac{740}{3} \times \frac{39}{4} \times \frac{16}{3}}{\frac{37}{4}}$$

Dropping the *denominators* which are above the line to positions under it, and transferring that *denominator* which is below the line above it we get

$$\frac{67 \quad 20 \quad 13 \quad 2}{201 \times 740 \times 39 \times 16 \times 4} =$$
$$8 \times 3 \times 4 \times 3 \times 37$$

$$67 \times 20 \times 13 \times 2 = 34{,}840\ lb.$$

Answers to Last Week's Questions

1. $\frac{36}{144} = \frac{8}{12} = \frac{2}{3}$.
2. $\frac{231}{1728} = \frac{77}{576}$.
3. $\frac{3072}{24576} = \frac{1}{8}$.
4. $\frac{(64 - 12) \times 40}{2240} = \frac{52 \times 40}{2240} = \frac{13}{14}$.
5. 1.
6. $\frac{1}{3}$.
7. $\frac{12}{42} = \frac{2}{7}$.
8. $\frac{6000}{12000} = \frac{2}{3}$, $\frac{6000}{12000} = \frac{1}{2}$, $\frac{3400}{12000} = \frac{17}{60}$.
9. $\frac{1}{4}$.
10. $\frac{1}{3}$.
11. $\frac{69}{72} = \frac{23}{24}$.
12. $\frac{165}{1155} = \frac{33}{231} = \frac{11}{77} = \frac{1}{7}$.
13. $\frac{275 \times 90}{33{,}000} = \frac{24750}{33000} = \frac{825}{1100} = \frac{75}{100} = \frac{3}{4}$.

Examples for Practice

1. What is the weight of 2712-in. of 4-in. wrought-iron pipe if it weighs $10^{23}/_{50}$ lb. per ft.?

2. A 225-hp. engine consumes $3\frac{5}{8}$ lb. of steam per hr. per hp. How many pounds will it consume if run $2^{4}/_{5}$ days of 10 hr. each?

3. A boiler grate contains $56^{25}/_{29}$ sq.ft. of surface. If $8^{4}/_{5}$ lb. of coal can be burned per square foot in 1 hr., how many pounds can be burned in 9⅞ hr.?

(4) An engine that has been running $2^{3}/_{5}$ hr. has been running how many times longer than one that has been running $\frac{8}{10}$ hr.?

(5) How many tubes does a boiler contain if its total heating surface is 2133⅓ sq.ft. and each tube has $^{64}/_{3}$ sq.ft. of surface?

(6) How many washers each $^{3}/_{64}$ in. thick can be strung on a bolt that is $^{9}/_{8}$ in. long from inside of the head to inside of the nut?

American Coal Abroad

The value of the U. S. coal sent to foreign countries in the last fiscal year was $52,500,000 against $21,000,000 in 1902 and $8,500,000 in 1892, having thus increased over 500 per cent. in the last 20 years and 150 per cent. in the last decade. Even these large figures of coal sent to foreign countries in the fiscal year 1912 do not include the value of that passing out of the country in the form of "bunker" or fuel coal laden on vessels engaged in the foreign trade, which aggregated nearly $23,000,000 in value, making a total of over $75,000,000.

The quantity sent to foreign countries in 1912 was, according to figures compiled by the Department of Commerce and Labor, 17,500,000 tons. The quantity exported in 1912 is over six times as much as in 1892.

Coke exports also show a decided growth, the value in 1892 having been $112,000 and in 1912 $3,000,000.

The fact that the coal sent to foreign countries has increased 150 per cent. both in quantity and value, during the last 10 years, and that the total value of exports to foreign countries plus the value of that leaving the country as bunker coal now aggregates over $75,000,000 suggests that the total value of the coal passing out of the United States in a single year will soon reach the $100,000,000 line.

Steam Engine Breakdown Lessons

By H. S. Knowlton

A number of steam engine failures; an analysis of the causes responsible for them; and recommendations showing how they could have been prevented by a little forethought.

The following notes, condensed from the records of a large accident-insurance company, review the more important facts bearing upon various steam-engine failures occurring during the past year, and suggest in a number of cases, defects in design or operation which should be avoided in future work.

Water in the Cylinder

The bottom of the low-pressure cylinder of a vertical compound engine was fractured, probably through the entrance of water. As shown in Fig. 1, the cylinder exhausted through a 6.5-ft. length of pipe into a jet condenser. After an inspection of the air pump the engineer opened the injection valve *C*, and then the engine

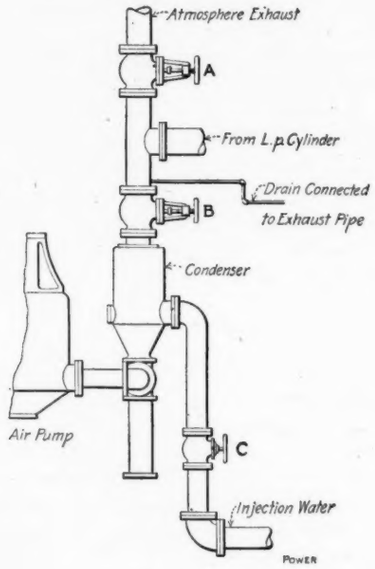


Fig. 1

stop valve, slowly starting the engine. He then opened the valve *B* and shut the atmospheric valve *A*, and at once the low-pressure cylinder bottom was fractured circumferentially at the stuffing-box and at the inner edge of the flange. The latter was also cracked radially through 17 of the 18 bolt-holes, and the center boss of the piston was torn out.

A careful examination of the broken parts failed to disclose any indication of the presence of any foreign substance between the piston and the cylinder bottom, or any abrasion of the cylinder bore. It was difficult to learn how the water reached the low-pressure cylinder, but it was reasonably certain that it did not come through the main steam lines, since these were carefully designed, falling to a separator near the engine, which had a glass water gage and trap drain. It was thought that the water might have come from the atmospheric exhaust pipe or from the condenser. In the former case, as the engine had been running noncondensing for a considerable period, water must have accumulated in the lower part of the exhaust pipe above the valve *B*, and may have risen to overflow into the valve chest.

As long as the engine ran slowly the water trapped in the cylinder at the beginning of the compression would have been forced through the drain *E* into the exhaust pipe and back into the steam chest, but when the speed increased, the drain no longer was sufficient to handle the water.

A drain just above the valve *B*, to be opened when working noncondensing, would have prevented an accident of this kind. It also seemed possible that the trouble may have been due to the improper handling of the valves by which water from the injection pipe rushed into the condenser and upward into the low-pressure cylinder.

Turbine Accident

An accident to a turbine emphasized the importance of automatic drainage of steam piping. In this case the turbine was of the exhaust type, connected to the low-pressure cylinders of an engine plant of about 1000-hp. rating, with a supplementary steam connection through which

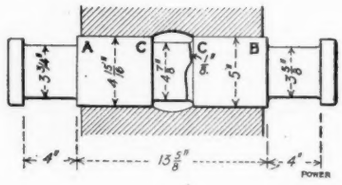


Fig. 2

boiler steam reduced in pressure could be supplied when the load upon the engines was too small to furnish the turbine with the necessary quantity of exhaust. The turbine ran at 3000 r.p.m., and exhausted into a surface condenser with the circulating and air pumps driven by a small compound engine. When operating with most of the equipment shut down, the 4½-in. blades of the thirteenth runner were all stripped, and many other blades were bent. The corresponding rows of fixed blades were also damaged, and several of the condenser tubes immediately below the steam inlet were considerably damaged.

The most probable cause of the accident appeared to be entrained water coming from the steam pipe. This pipe was 10-in. in diameter and 5 ft. long, and being uncovered served to condense much of the steam. It was undrained except by a tap, which was never opened when the turbine was working. There appeared to be no reason why water could not readily accumulate in this pipe and back up at the end next the turbine until carried forward in a mass by the steam current. After the accident the pipe was replaced

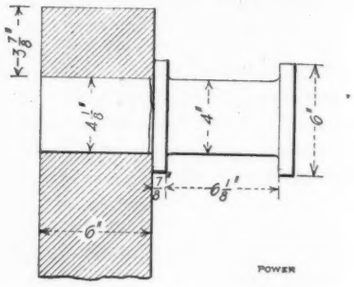


Fig. 3

by another connected with a well drained automatically by a trap.

Beam Engine Failure

A failure in a beam-engine gudgeon occurred recently, illustrating the importance of looking after the wear and strength of all moving parts when modernizing an old prime mover. The engine had been rebuilt sufficiently to permit raising the boiler pressure to 130 lb., and the load upon the piston was increased to 50,000 lb. Unfortunately, the gudgeon in the beam was not replaced, although attention was drawn to it by rust working out between the gudgeon and the boss. It was found to be loose and when taken out, was seen to be broken, as shown in the illustration.

Measurements showed that both the gudgeon and the inside surface of the boss holding it were worn about $^1/_{64}$ in. at *A* and *B*, Fig. 2, so that the gudgeon, when free from the strain was gripped only by the beam at *CC*, and could receive no support from the outer parts of the boss unless strained about $^1/_{64}$ in. The gudgeon was thus in the position of a beam supported at the journals and loaded at two points each about 1⅝ in. from the center. Under such conditions, the load of 50,000 lb. upon the piston would at times produce a stress of about 16,000 lb. per sq.in. at the top and bottom surface of the gudgeon.

Crankpin Failure

A crankpin failure resulted from the use of a poor and rather antiquated design. The engine was of the horizontal tandem-compound type running at 74 r.p.m. under 30 lb. steam pressure. The pin was of wrought iron of the dimensions shown in Fig. 3 without a fillet at the back of the collar, and it was shrunk into a wrought-iron crank. The strain produced by the grip of the crank, combined with the abrupt change of sectional area, started a crack close behind the collar which gradually extended until the pin severed more than half through and gave way. The load upon the pin was about 20,000 lb., giving a bending stress of about 1500 lb. per sq.in.

It was estimated by the engineer of the accident-insurance company that the

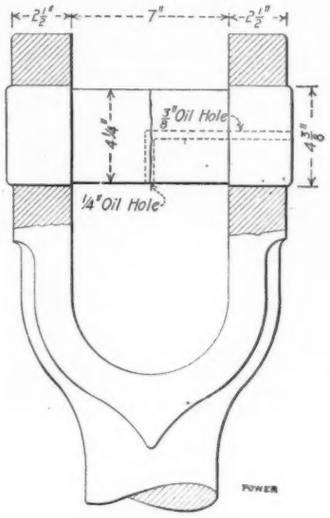


Fig. 4

shearing stress due to the shrinkage of the crank was probably sufficient to compress the shaft where the crank gripped it, and thus tear it away from the collar. The point was emphasized that where shrinkage is employed, the diameter of that part of the internal piece upon which the external part is to bear should be slightly larger than the diameter of the adjacent parts, and that the part of enlarged diameter should be entirely covered by the external piece.

Fracture of Crosshead Pin

An accident to a crosshead occurred in a 21x48-in. vertical engine running at 76 r.p.m. The pin coupling the piston-rod crosshead to the connecting-rod was of steel, and was fixed in the forked end of the latter, as shown by Fig. 4. The fracture lay entirely in a plane at right angles to the axis of the pin and had apparently started at the oil hole and worked its way through. It appeared that if the ¼-in. hole had coincided with a horizontal instead of a vertical diameter, and cut through the least instead of the most highly stressed fibers of the pin, it might have done no harm, and probably would have lubricated the surface fully as well.

Connecting-rod Failures

Cross-bending stress produced by the centrifugal tendency of the connecting-rod and cap appeared to be responsible for the failure of a 7½x6-in. vertical,

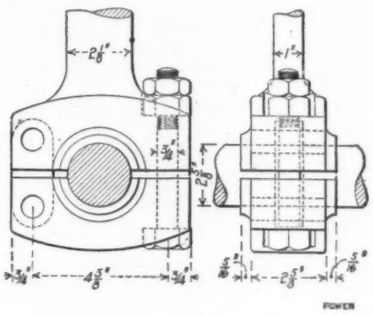


Fig. 5

single-acting, noncondensing engine running at 465 r.p.m. The connecting-rods were 15 in. long and weighed about 40 lb., the larger ends being made as shown in Fig. 5. The caps were held by a link hinge on one side of the bearing and a ¾-in. bolt on the other. The bolt in one of the rods broke at the bottom of the first thread, and the failure of the rod end followed. The bending stress upon the bolt was estimated at 6100 lb. per sq.in., and it was believed that the engine had made about 200,000,000 revolutions since the bolt was new. The significant point was the magnitude of the cross-bending stresses to which the connecting-rod bolts of rapidly running engines may be subjected.

A connecting-rod fracture occurred in the operation of a horizontal, noncondensing engine running at 92 r.p.m., under a steam pressure of 40 lb. The strap at the crosshead end of the connecting-rod broke through the bend, as shown in Fig. 6, resulting in a broken cylinder

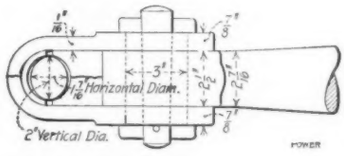


Fig. 6

cover and bedplate and a bent connecting-rod. An examination showed that the crosshead pin was oval, its vertical and horizontal diameters measuring 2 in. and 1⅞ in. respectively, and it was found that new brasses had been fitted about seven weeks before the breakdown.

From measurements of these after the breakdown it appeared that they had been bored to the horizontal diameter of the pin, and when first put in must have touched the pin only on the top and bottom. Thus fitted, they became powerful wedges, and under the action of the piston a fracture of the strap naturally followed. This fracture was not new, but it was uncertain whether it began before or after the new brasses had been placed in service. The pin was loose in the crosshead, and revolved in it freely instead of in the brasses; otherwise overheating would have been experienced with the brasses wedged at the top and bottom between the pin and the strap.

Breakage of Air Pump Crosshead

Fig. 7 shows the details of an air-pump crosshead connection which failed on account of the wear on the journals to which the links from connecting bell-crank levers were coupled, the air pump being driven from the piston-rod crosshead by links and bell cranks. One of the air-pump crosshead arms broke close to the central socket into which the rod was cottered. The original diameter of the journals had been 2 in., but when the crosshead failed, they measured 1¼ in. vertically and 1⅝ in. horizontally, as

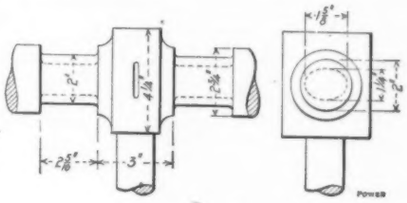


Fig. 7

indicated in the illustration. Not only was the crosshead weak, but the stress upon it was greater than under ordinary conditions for the reason that the overflow pipe from the hotwell was not provided with a continuous drop to its outlet, but dipped downward to clear a thoroughfare, later rising again and permitting the accumulation of a column of water which had to be accelerated at every stroke of the air pump. Furthermore, the space for the cooling water was so limited that the temperature of injection was high, necessitating the pumping of an unusually large volume of water for this service.

This point had been emphasized a few years before, when the engine was insured, and it had been suggested that the engine should discharge into a tank, a centrifugal pump being employed to lift the water into a pond or cooling tower. As the journals were never stripped when the insurance inspector visited the plant, there was no opportunity to discover their condition, and knocking had been prevented by packing the brasses with leather, the owners being unwilling to purchase a new crosshead.

"It'll be a cold day when you get me to work again!" remarked the radiator to the reducing valve.

Fuess Steam Meter

Steam which meets obstruction in a pipe line will suffer a certain loss in pressure. If the obstruction is permanent and not changeable, a certain loss in pressure will correspond with a certain velocity of steam. It is therefore possible to measure the velocity of steam by means of reducing the pressure if the relationship between these two factors is known. In the steam meter made by R. Fuess, of Germany, who is represented in this country by H. Bacharach, of Pittsburgh, this physical process was adopted.

The reduction of the inside pipe section is accomplished by a throttling disk or a plate, with an opening smaller in diameter than the pipe, located between two flanges. The steam at this point loses part of its pressure, but the shape of the throttling disk and the reduction in the pipe section is so calculated that the loss in pressure at the highest steam velocity will not exceed 1½ lb.

To measure the loss in pressure a mercury differential manometer is used. It consists of a straight glass tube, the lower end of which is connected with a receptacle of a large surface. By connecting the tube of the mercury manometer, Fig. 1, with the steam line in front of the throttling disk and the receptacle of the manometer with the steam line back of the disk by means of small tubes filled with water, the difference of pressure in front and back of the throttling disk

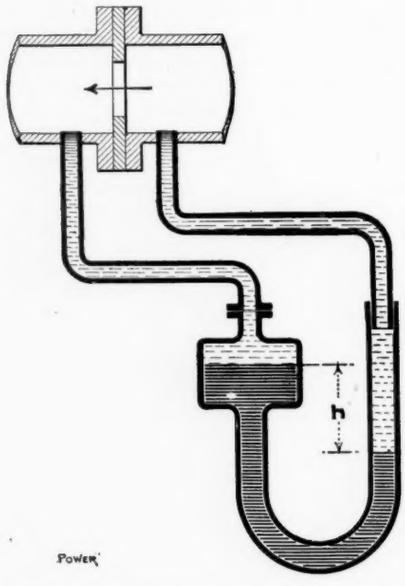


FIG. 1. ILLUSTRATING PRINCIPLE OF OPERATION

will effect a lowering of the mercury in the manometer tube. The difference in the height, h, gives the means to ascertain the loss in pressure.

Through research work it was found that the quantity of the steam G has the following relation to the loss in pressure h.

$$G = 151.2\, K q \sqrt{\frac{p \times h}{p_o \times S}}$$

where

G = Quantity of steam;

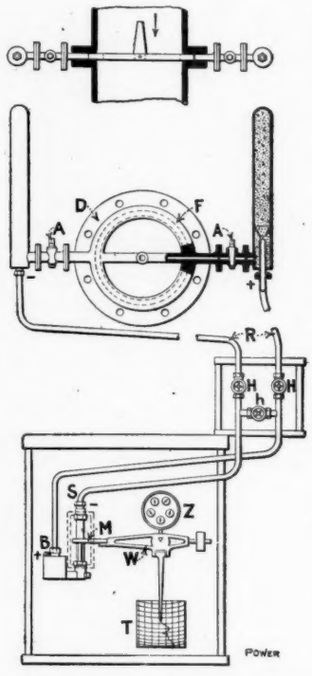


FIG. 2. SKETCH OF METER AND CONNECTIONS

K = Constant depending on the size of the opening in the throttling disk;

q = Cross-section of throttling disk;

p = Steam pressure in front of throttling disk;

p_o = Steam pressure back of throttling disk;

$h = (p - p_o)$ = Difference in pressure measured at the mercury manometer;

S = Specific gravity.

The quotient $\frac{p}{p_o}$ given under the square root sign is always close to 1 on account of the difference between p and p_o never exceeding 1½ lb. The specific gravity of the steam, while changeable with increase or decrease of pressure and, when using superheated steam, with the increase and decrease of temperature, will not change so much as to have a noticeable influence on the measuring of steam. Constant conditions of steam to secure regular and satisfactory operation may usually be expected in a certain plant, so that it is permissable to use for S a certain standard factor corresponding with the standard steam conditions and insert this factor in the above formula. Besides G and h all other values in the formula are unchangeable for a certain steam line. They can, therefore, be combined for this steam line to a constant K, thus obtaining the following simplified formula:

$$G = K\sqrt{h}$$

This constant K is sent with each steam meter and it is only necessary to extract the square root of the reading taken on the manometer board and multiply it by K, to obtain the amount of steam flowing through the line expressed in pounds per hour. The coefficient K holds good only for a certain condition of steam or at least for one which varies only in very narrow limits. In cases where the steam line has, at a certain time, a pressure of, say, 140 lb., and then of, say, 70 lb., a different constant K has to be used for each pressure. It is therefore possible to apply the meter to different steam lines by using a different constant for each one.

For a continuous record, the amount of steam flowing is recorded automatically on a chart. Wherever it is intended to find the total amount of steam used during a specified period a counter has to be used.

A sketch of the instrument as actually installed is shown in Fig. 2. A throttling disk F is inserted between two flanges of the steam line D. Across the disk is a bridge which has one opening in the center at the front and one at the rear. The two openings do not communicate with each other but are carried through the disk separately and connect to the cocks A and A. From each of these cocks a line R leads to the valves H

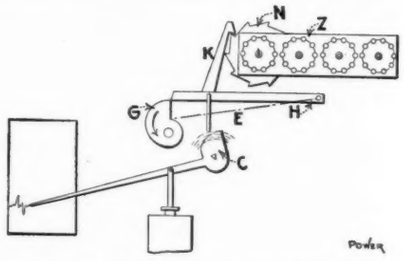


FIG. 3. MECHANISM OF COUNTER

which, in turn, are connected to the mercury manometer at B and S. The narrow leg of the manometer is made of glass and the wide one of iron. The line is filled with water which reaches down to the mercury in the manometer. A small cylinder floats on top of the mercury in the narrow leg and is embedded in glass to prevent corrosion. This small piece of iron is the core of a permanent magnet which is connected with the balance lever W. The latter carries a pen which gives the record on drum T.

The valves H shut off the meter while valve h equalizes the pressure in both legs and adjusts the recording pen to the zero position.

To avoid planimetering the daily charts, a counter Z is connected to the apparatus which integrates automatically the differ-

ent amounts recorded on the diagram. The construction and working of this apparatus, shown in Fig. 3, is as follows:

A small clock movement releases every minute another clock movement which again releases, through cam *G*, the lever *H*. The latter actuates, by means of the ratchet *K*, the counter *NZ*. The upper stop of lever *H* is fixed, the lower depends upon the position of the metal piece *C* which is connected to the balance lever *W*, Fig. 2. The shape of this piece depends upon the velocity of the steam

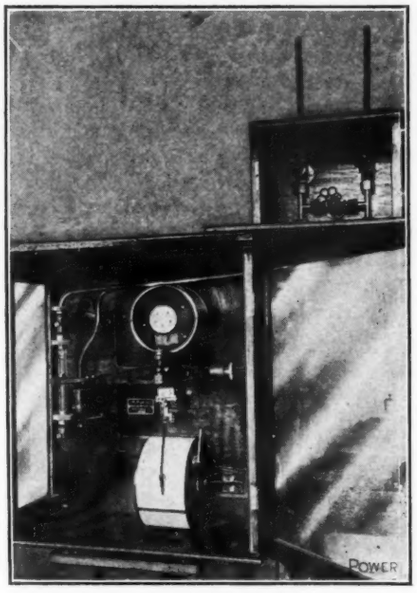


FIG. 4. A PHOTOGRAPH OF THE METER

and the area of the main line. High velocities cause large up and down movements of *E* corresponding to a large stroke of the counter; a low velocity, on the other hand, causes small up and down movements and a corresponding smaller record of the counter. This makes it possible for the reading of the counter to be taken in cubic feet as in a gas meter.

The correctness of the record depends, in the first place, upon the constant weight of the steam to be measured. But since this weight varies with varying temperature and pressure, the apparatus can only give exact readings for one certain temperature and pressure. For large variations, the readings must be corrected correspondingly.

Boiler Burned Out by Neglect

About two-thirds of the plant of the New England Pin Co., Winsted, Conn., was shut down recently owing to the burning out of a boiler. The man in charge at night had opened the blowoff valve and when it was closed some obstruction lodged on the seat which allowed the boiler to drain dry.

An hour's good firing failing to show pressure on the gage, the man asked the aid of a brother watchman in an adjoining plant and his investigation showed a dry and very hot boiler. The fire was covered very heavily and everything done to cool the boiler off. Then, acting as far as his conscience would allow, he advised the man to report immediately to his chief.

The boiler inspectors found all tubes needing expanding and a girth seam leaking very badly. The heat which showed on the shell after the fire was covered was from red to white.

Boiler Explosion in Heating Plant

The boiler in the heating plant of the Salem Bank & Trust Co.'s Bldg., Salem, Ore., exploded on Oct. 27. One man was killed and two were injured. One of the injured was hurled through a heavy plate glass window, landing in a hole several feet below the sidewalk that had been made by the force of the impact of the explosion. The damage to the building and heating system will amount to several thousand dollars, nearly every plate glass window in the building being blown out.

The boiler was of the cast-steel sectional type made by the American Boiler Co., and had been in service for the Oregon State Insane Asylum, and was considered in first-class condition. It is the opinion of local engineers that had the heating system been in charge of a competent engineer, the accident would never have occurred.

No Power Show for 1913

Many conditions influenced the National Exhibitors' Association of Commercial Engineers against holding a power show in 1913. The Textile Exhibitors' Association will not hold an exhibition of textile machinery such as was held last April, and with which the power show was allied. Then, again, the National Exhibitors' Association is to hold its annual exhibition of power-plant apparatus, machinery and supplies at Springfield in September, 1913, at the same time as will be held the annual convention of the National Association of Stationary Engineers; the Universal Craftsmen, Council of Engineers, holds its convention in Boston in August, 1913, and it may be that an exhibition will be held in conjunction therewith, and the Massachusetts State Association of the N. A. S. E. convention and exhibition is to be held in Lawrence during July, 1913. All these matters being taken into consideration it was the general opinion of the members that the holding of a power show would not be advisable.

Over the Spillway

Just Jests, Jabs, Joshes and Jumbles

Yes, it's Wilson, a good brand. Never mind now how we voted, it's up to us to dig in all the harder and look pleasant. Then these good old United States will continue to be God's country.

An Oklahoman complains that his town's electric-lighting service is too darn good; his fowls don't know when it's dark and won't go to roost. We have in mind several old roosters who are similarly afflicted. Sounds like a fowl joke!

Mayme Pixley, a young Indiana woman, is getting all the big contracts in her home state to paint the lighting-plant and distillery smoke-stacks. "My Pappy got hurt, and I took up his trade." Hooray for Mayme!

"Be proud of your calling," advises *Valve World*, and it quotes a speaker as saying: "I am not a banker or a broker; I'm just a plumber." Great Crœsus! If some of us engineers were plumbers, we'd be hiring bankers and brokers to take care of our money.

HORAN—Why do they be sayin' "the unspeakable Turk," Terry?

DORAN—That's aisy. Ye can't pronounce th' names they has. The half ov thim looks loike the chimical symbol for Good's sassyparilly.

Hi Sibley has a blast in the *American Machinist* anent the factory-whistle nuisance. He suggests a calliope playing topical songs to cheer the ear-weary employee. We joyously trotted behind the circus calliope in our infantile days, but, now—good night!

The government fed the engineers on the Panama Canal $111,000 worth of ice cream last year. It kept one plant continuously busy.

One of the moving-picture fraternity has bought two switching locomotives and will sic one on the other in a "head-on" collision, replacing the engineer with dummies after the engines are under headway. The "villain" (another dummy) is to be ground into goulash and presumably not enough of the old pushers will be left to furnish kindling to light a gas stove. Now let's have a "fillum" that makes a hero of the operating engineer; then there should be action aplenty.

A. S. M. E. Meeting in Germany

The plans for the meeting of the American Society of Mechanical Engineers with the Verein deutscher Ingenieure, in 1913, which promises to be the most remarkable tour of the industries in Germany ever offered to American engineers, are being most satisfactorily arranged. Conrad Matschoss, dozent of the Royal Polytechnic High School of Berlin, has been visiting the United States as a representative of the German society and has been conferring with the committee of arrangements regarding itinerary professional papers, etc.

June 11 will be the date of departure. The party will arrive in Germany on Saturday, June 21, be received by the municipal authorities and given an opportunity to visit the great shipyards before going on by special train to Leipzig the same or the following day.

Sunday evening, June 22, there will be an informal gathering to promote acquaintanceship before the formal opening on Monday, June 23. At this opening the visitors will be welcomed by the King of Saxony and the municipal authorities of Leipzig, and two addresses, one by a representative of the German and the other by a representative of the American society which will be on general subjects, as the history of engineering, relation of capital and labor, and effect on industry of technical education.

Tuesday, the last day to be spent in Leipzig, will be devoted to technical papers, to various social events and participating in the patriotic gathering in commemoration of the one hundredth anniversary of the battle of Leipzig.

On Wednesday the party will leave for a tour of industrial Germany, visiting the principal cities, Dresden, Berlin, Düsseldorf, Cologne, Frankfurt, Nürnberg, Munich, etc. In all probability, the Krupp Works will be thrown open to the party, the Baroness von Bohlen (formerly Miss Krupp) receiving the visiting American engineers in person. After the trip up the Rhine from Bonn to Rüdesheim, there will be a grand festival on the Rüdesheim embankments. Independence Day will be celebrated at Frankfurt under the auspices of the American Embassy.

The final meeting will be held in Munich, July 7, in connection with the Museum of Technical Arts, of which Dr. von Miller is the director. It is expected that the Prince of Bavaria and the Mayor of Munich will also receive the party. The entire trip through Germany and the various official receptions are being arranged by a committee of prominent men of the arts and sciences in the German society and much interest is being shown by municipal authorities and the heads of industrial establishments.

The itinerary of the visit of the American society will be as follows:

June 21. Reception at the landing-place by the local board.

June 22. Leipzig, official reception by the Verein deutscher Ingenieure.

June 23, 24. Participation in the exercises of the annual meeting.

June 25. Dresden.

June 27, 28. Berlin.

June 29. Düsseldorf. Reception by the Rhine-Westphalian Section of the Verein.

June 30 to July 2. Various functions arranged by the Rhine-Westphalian Section, and trip to Cologne and Essen.

July 3. By railway to Bonn. By boat up the Rhine, with festival at Rüdesheim. By rail to Frankfurt, arriving about 6 p.m. Evening, reception of welcome at Frankfurt.

July 4. Independence Day at Frankfurt.

July 5. Nürnberg.

July 6. Munich. Evening, reception of welcome.

July 7. Morning, visit to the German Museum. Evening, trip on the Starnberg Lake. Final exercises in the Rathaus.

Heating Engineers to Meet at Indianapolis

The executive committee of the National District Heating Association met in its mid-year session in the city of Indianapolis, Ind., on Oct. 30 and 31, to arrange the program for the fifth annual convention and to fix the time and place for holding that convention in 1913. Indianapolis, Ind., was unanimously selected and the time set for May 27, 28 and 29, with headquarters at the Claypool Hotel. Papers upon the following subjects were arranged for the convention: "District Heating on the Pacific Coast," "Possibilities of Hot Water Heating," "Line Condensation in Different Forms of Construction," "Results of Using Bleeder Turbines," "Appraisal of Heating Properties," "Station Designs with Special Reference to Overload Capacities," "Uses and Abuses of Public Service Commissions," "Hot Water Heating for Residence Districts," "Public Policy;" also two other papers, the subjects to be announced later. In addition, reports were asked for from the standing committee on meters, station records and rates, the report of the committee on meters to call for experience of those stations that have changed over from flat rate to meter rate.

The largest screw power-testing machine in the world, capable of carrying 1,000,000 lb. on two screws, has just been shipped by the Riehlé Bros. Testing Machine Co., Philadelphia, Penn., to the American Steel Foundries, Alliance, Ohio.

Educational Work of Newark Association No. 3

Newark (N. J.) Association No. 3 has begun its winter educational classes in subjects that apply to power-plant operation. The course will include a review of essential mathematics; thermodynamics, as heat losses in engine and boiler practice, and means for diminishing them; furnace efficiency; economic combustion of fuel; draft; flue-gas analysis, etc. The engineering problems will embrace the efficiency of boiler joints, allowable and safe working pressures, heating surfaces, and horsepower of boilers, and the need of greater safety in operation, minimizing the possibilities of boiler explosions, will be brought forward.

The class is under the supervision of Charles H. Bromley, associate editor of POWER. Edward Sears and C. L. Johnson, members of No. 3, are engaged in designing two power plants, the plans and specifications for which will be discussed by all the members.

Ohio Mechanical, Electrical and Steam Engineers' Convention

The twenty-sixth meeting (eleventh annual meeting) of the Ohio Society of Mechanical, Electrical and Steam Engineers will be held, Nov. 21, 22 and 23, at Akron, Ohio, with headquarters at the Hotel Portage. The program is as follows:

THURSDAY. 1-2 p.m.—Registration.

2:30 p.m.—Trolley-car trip to the Wellman-Seaver-Morgan Co., manufacturer of large power machinery.

7:30 p.m.—Informal reception in Hotel Portage, to meet the Akron Branch, N. A. S. E., and the Universal Craftsman Council of Engineers.

8 p.m.—Address of welcome, by F. W. Rockwell, Sr., mayor of Akron; "The City of Opportunity," by S. F. Ziliox, president Akron Chamber of Commerce. Response by E. M. Adams, president of the society.

8:30 p.m.—"A System of Gas Engine Governing," by George S. Cooper, mechanical engineer, Buckeye Engine Co., Salem, Ohio; "The Lentz System Applied to Steam Engines," by Siegfried Rosenzweig, mechanical and consulting engineer, Erie City Iron Works, Erie, Penn.

FRIDAY. 9 a.m.—A trip of inspection through the mammoth plant of the B. F. Goodrich Rubber Co.

1:30 p.m.—Take cars for Barberton, Ohio, and visit the Babcock & Wilcox Co.

6 p.m.—Complimentary dinner at Hotel Portage. Visiting members and ladies will be the guests of the Akron members.

7:30 p.m.—Business session in Hotel Portage. Election of officers.

8 p.m.—"The Manufacture of Tin Plate," by Ed. W. Patton, master mechanic, Follansbee Bros. Co., Follansbee, W. Va.

SATURDAY. 9 a.m.—Trolley-car trip to the new power stations of the Northern Ohio Power Co., at the Gorge.

Ladies' program, Thursday, 2:30 p.m.—Automobile trip through the residential districts of Akron.

8 p.m.—Theater party at Colonial Theater. Vaudeville.

Friday, 9 a.m.—Visits to several Akron schools.

2 p.m.—Automobile ride around the lakes.

6 p.m.—Complimentary dinner.

8 p.m.—Guests at the meeting for paper No. 182.

Saturday, 9 a.m.—Visit to O. C. Barber's farm at Barberton, Ohio.

OBITUARY

REUBEN WELLS

Reuben Wells, a veteran railroad man, one of the ablest locomotive constructors in this country and for 20 years superintendent of the Rogers Locomotive Works, died at his home, 202 Carroll St., Paterson, N. J., on Nov. 8.

Mr. Wells was born in Pennsylvania, Jan. 1, 1829. At seventeen he entered the works of the Reading company as a machinist apprentice. After finishing his trade, Mr. Wells was sent out as an engineer to run a train in the coal regions between Palo Alto and Port Richmond. As was the custom, he was given an engine which no experienced man would run if he could get a better one, but young Wells made as good a record with the discarded engine as did the others with the better ones.

He was with the Reading until July, 1851, when he went to Columbus, Ohio, as engineer on the Columbus & Xenia R.R., remaining until September. He next became connected with the Rushville & Shelbyville R.R., which was 20 miles long and about 30 miles southeast of Indianapolis. This road had a "strap rail" track. The rolling-stock consisted of one locomotive, two passenger coaches and 30 freight cars and Mr. Wells made one round trip a day. In June, 1852, he was master mechanic of the Jefferson & Indianapolis R.R., and later with the Jefferson, Madison & Indianapolis R.R., where he remained for 26 years, and then was superintendent of the Louisville & Nashville R.R.

In 1868, Mr. Wells designed the first locomotive for grade climbing; it was used on incline work at Madison, Ind. Up to that time it required locomotives with four pairs of drivers and two vertical cylinders, with a pinion wheel working into a "rack" between the rails of the track, which was a slow method. Mr. Wells invented a locomotive in July, 1868, with a tank engine and two cylinders, five pairs of coupled drivers, no truck and with side tanks for water; and it remained in service for 20 years. This locomotive was sent to the "Locomotive Museum" of the Purdue University, at Lafayette, Ind.

In 1873, Mr. Wells was appointed a trustee of Purdue University by the governor of Indiana to represent the mechanical interests of the state. In 1878 he went to Kentucky as superintendent of machinery of the Louisville & Nashville R.R. system, in 1885 becoming general manager and in 1886 second assistant to the president.

Mr. Wells once changed the gage of 1762 miles of track within 20 hours, making the change from the regulation 5-ft. gage to 4 ft. 8½ in., the gage of practically all the other roads in the country.

REUBEN WELLS

It was in 1887 that Mr. Wells left the Louisville & Nashville R.R. to accept the position of manager and superintendent of the Rogers Locomotive Works in Paterson.

Throughout his career he maintained the excellent standard he had set for himself, and for 57 years he was constantly at work and rising to higher positions.

Mr. Wells was a devoted family man and always took an active interest in his business. The late Jacob Rogers, principal owner of the Rogers plant, considered Mr. Wells' services invaluable, and always reposed the most explicit confidence in him. Thousands of Paterson mechanics now working elsewhere were under Mr. Wells' supervision, and by all he was held in high esteem.

He is survived by his widow, two daughters, and two step-sons.

SOCIETY NOTES

At the regular November meeting of the Detroit Engineering Society, held in the hall of the Detroit Wheelman's Club on Friday evening, Nov. 15, Henry Hess, of the Libby Glass Co., of Toledo, Ohio, read a paper entitled "Glass." A light buffet lunch was served after the meeting.

Charles L. Huston, of the Lukens Iron & Steel Co., will give an illustrated lecture on "The Manufacture of Steel Boiler Plate" before the American Institute of Steam Boiler Inspectors at the Engineering Societies Building, 29 West Thirty-ninth St., New York, on Friday evening, Nov. 29. As Mr. Huston is one of the foremost authorities on this subject, the lecture should prove both interesting and instructive, and a large attendance is looked for.

PERSONAL

R. F. Pack, general manager of the Minneapolis General Electric Co., has been appointed a member of the Smoke Prevention Committee of the Minneapolis Civic and Commerce Association.

Corneil Ridderhof, formerly general manager and treasurer of the Wilmarth & Morman Co., Grand Rapids, Mich., is now with the Western Gas Engine Corporation, Los Angeles, Calif., as assistant general manager.

Alfred Johnson, chief engineer of a large department-store building in Chicago and prominent in N. A. S. E. affairs, and John W. Lane, editor of the *National Engineer*, left Chicago on Nov. 14 for a visit to the Panama Canal.

C. E. Fairbanks has been promoted to master mechanic for the Gorham Manufacturing Co., at Providence, R. I. He will take charge of all the mechanical equipment and continue in charge of the company's electrical matters.

Gove S. Taylor has accepted the position of special representative in the Pittsburgh and surrounding territory for the Magnolia Metal Co., New York City. Mr. Taylor was for years manager of the Peerless Rubber Manufacturing Co., and is widely known to the mill-supply and power-plant trade.

B. F. Eyer, who founded the department of electrical engineering in the Kansas State Agricultural College, has resigned and will enter commercial life, Jan. 1. Prof. Eyer was a teacher of physics and chemistry in the Topeka high school for five years and was vice-principal in that school when he resigned to come to the Kansas State College. He is a member of the American Institute of Electrical Engineers, the National Electric Light Association, and a past president of the Kansas Electric Light Association.

Moments with the Ad. Editor

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